STUDY OF THE DESERT TORTOISE, *Gopherus agassizi*, AT THE GOFFS PLOT: SPRING, 1980

July 30, 1980

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In fulfillment of Contract # CA-060-CT0-7

Bureau of Land Management

1695 Spruce Street

Riverside, California 92507

LIST OF ACCOMPANYING MATERIALS

1. Field Journal.
2. 35 mm, colored slides of tortoises and habitat. These are incomplete because of losses in the mail.
3. Aerial photograph of the study plot with an overlay on which the approximate study plot boundary is drawn.
4. Five vellum maps which together include all capture and recapture points of each tortoise found on the study plot between 29 March and 12 June 1980. (22½ x 24 inches; scale: 1 inch=100 m)
5. Skeletal remains found on the study plot.
6. Individual data sheets for tortoises found on study plot during spring 1980.

Abstract. During 69 days between 29 March and 12 June 1980, 297 tortoises were seen on the Goffs study plot: 96, 64% of all tortoises marked in 1977 and 1978, were recaptured (81% of the previously marked adults); 201 tortoises were marked during 1980. Of all the tortoises seen, 54% were adults ($\geq$ 208 mm carapace length); 9% were subadults (180-207 mm). Juveniles 100-179 mm comprised 28%; those 60-99 mm, 7%; and those $<$ 60 mm, 2%. The ratio of males to females among tortoises $\geq$180 mm was 1.5:1. The best estimate of population density was 251 using the Jolly-Seber method which compensates for emigration and immigration an important consideration because presumably a portion of many of the tortoises home ranges extend outside the study plot boundary; each transient and partial year resident on the plot is marked when found and when various Lincoln Indices are used to estimate population density they appear to show the cumulative effect of this. Sign of predation and death included 9 shells. Four of them were recent juveniles and their conditions suggested predation as the cause of death. Five shells were of adults and subadults that may have been exposed for 1-3 years. Two recent clutches of eggs were found unearthed by predators and empty. Coyote scats (21) were negative for tortoise remains and none of the live tortoises showed sign of recent injury. Forage was abundant, the prostrate annual Lotus tomentellus was eaten on 72 of the 100 feeding observations involving tortoises in all size classes. Green, succulent Lotus was widely available through the first week in June and in the washes through 12 June. Two permanent belt transects were established and perennial and annual vegetation were analyzed for cover, density, and frequency values.

INTRODUCTION

The desert tortoise, Gopherus agassizi, is one of a number of species that appear to be sensitive to man's direct and indirect impact upon the desert. Part of the California Desert Plan Program of the Bureau of Land Management is land-use planning based upon evaluation of the population status, trends, and needs of sensitive species. Long-lived desert species such as the desert tortoise must withstand trends of climatic extremes that extend over several successive years; therefore determining species status after several successive years is a prerequisite to management decisions. To this end permanent study plots have been set up on public land from which data are being secured regarding tortoise densities, age structures, sex ratios, forage preferences, and other behavioral and ecological aspects. Permanent belt transects are being established on the sites from which density, frequency, and cover values of the vegetation can be gathered.

Studies at the Goffs plot began in the spring, 1977 when I spent 30 days at the site seeking out, marking, and releasing tortoises (Burge 1977a). In the spring of 1978, 7 days were spent at the site (Nicholson, 1978a). This report covers work performed during the spring 1980. From 29 March through 12 June I spent the equivalent of 60 full days searching for tortoises--marking those not previously marked, taking measurements, and observing behavior of all marked and unmarked tortoises. Permission to handle tortoises and collect remains was authorized by the State of California Department of Fish and Game (Scientific Collectors Permit # 4232).

SITE DESCRIPTION

The approximately 1 square mile (267 ha) study plot is essentially Section 8 of Township 9 N, Range 18 E; public land, 4 miles west and 3 miles south of Goffs, San Bernardino County (USGS 15' Quad: Fenner). Access is direct from Goffs Road by gas line and telephone line maintenance roads (Figure 1). The site is on bajada; average slope, 2%; aspect, south; average elevation, 2400 feet. In 1977 and 1980 attempts to locate section corner markers were unsuccessful; however, in 1980, bench mark 2391 was located between the highway and the railroad tracks (beyond the southeast corner of Section 8). Using the topographic Fenner 15' Quadrangle map the location of the SE corner of S8 was estimated by pacing northeast from the bench mark. This change in the location of the SE corner moved the south boundary of the study plot northward slightly off of Section 17 (private land) and equating it more closely to Section 8.

Two wash systems drained from the north; one extended along the western boundary; the other, joined a major wash system at the NE corner, continuing south-southwest, crossing the study area almost mid-way along the southern boundary. Here, the wash complex was $\approx$ ¼ mile wide with individual channels 15-60 m wide alternating with flats some of which were low and lichen-covered. The major wash system formed along the coalescence of the south facing alluvial fan on which the study area was located and a major fan sloping toward the west. Masses of natural debris and occasional human refuse (large cans and lumber) remain (from prior to 1977) partially imbedded on the flats and vegetated sand bars between the wash channels.

Figure 1. Access to the Goffs study plot.

40' contours
1:62,500

FENNER QUADRANGLE
CALIFORNIA–SAN BERNARDINO CO.
15 MINUTE SERIES (TOPOGRAPHIC)

ATE OF CALIFORNIA
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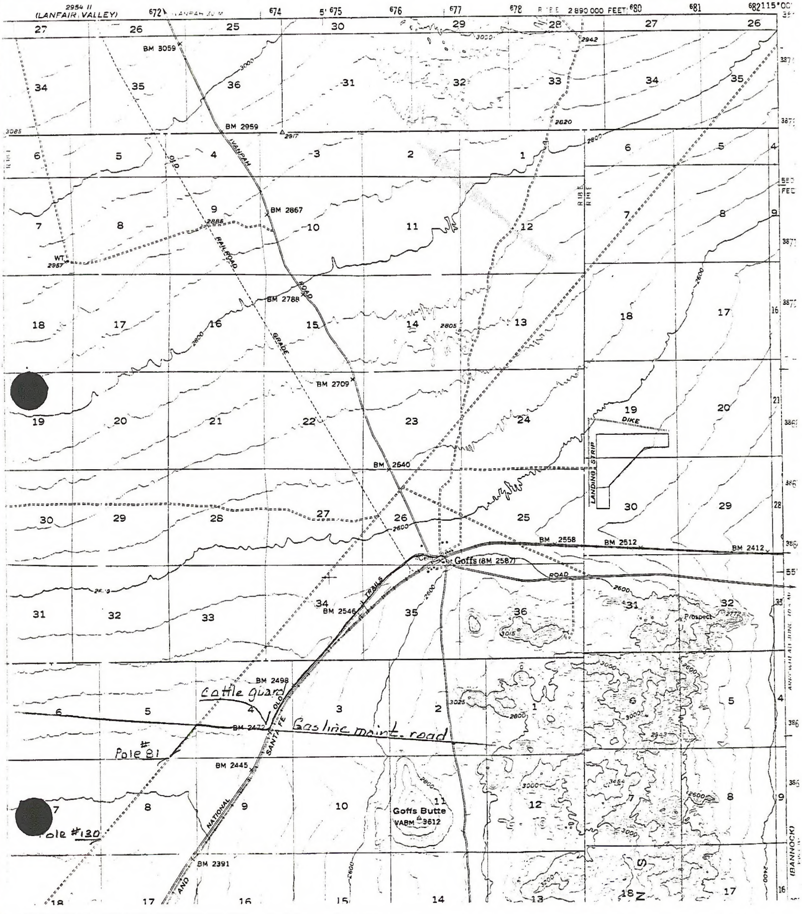


Most wash beds were of loose sand, flat, and nearly bare of vegetation. The banks were < 1 m high, a few were steep and free of vegetation; most were vegetated on the upper half. Dalea spinosa grew in the major wash. Along the banks, Larrea tridentata and Acacia greggii (2-3 m high) were dominant; also present were Hymenoclea salsola, and Salazaria mexicana. Cassia armata and Ephedra californica were less common. With the exception of Dalea spinosa, the species above also occurred along the wash complex in the NW corner.

In addition to the washes another type of feature interrupted the relatively smooth topography. This feature was termed a rise--nearly circular areas 6 - 30 m diameter, gradually sloping upward to a central area estimated at ≈ 1 m above the adjacent flats. The soil on the rises appeared to have more cobbles (65-100 mm diameter) lying within 1-5 cm of the surface than did the soil of the flats. About 25 of the rises were located at widely distributed points. Rises were a common site of burrow complexes dug and used by kit fox (Vulpes macrotis) and also used by tortoises.

On the sandy, felsic alluvium typical of most of the surface, pebbles > 4 cm were uncommon. Most exposed rocks (small boulders and large cobbles) were associated with areas of well developed, desert pavement which were widely distributed. Desert varnish was evident on pavement rocks which were moderately eroded and interspersed with colorful pebbles and small cobbles which included sandstone breccias, banded chalcedony, and fragments of quartz encrusted cavities.

The predominant perennial species of this Creosote Bush Scrub community, excluding washes, were Larrea tridentata, Ambrosia dumosa, Krameria parvifolia, Opuntia ramosissima, O. echinocarpa, and Hilaria rigida which was most common along the numerous shallow drainage channels. Almost without exception herbaceous perennials such as Stillingia linearifolia,

Palafoxia linearis, Porophyllum gracile, Coldenia plicata, Dyssodia cooperi, and the biennial Eriogonum fasciculatum were occasional and confined to drainage channels.

The dense, meter-high clumps of Hilaria were part of the dramatic change from 1977 when black stubble was the common form. Also numerous stumps of apparently dead Opuntia echinocarpa this year were studded with new growth. In contrast to 1977 annuals were abundant. The prostrate Lotus tomentellus and the grass, Schismus barbatus were the dominant under story in most areas. Another abundant species was Linanthus aureus decorus. Common species included Eriophyllum wallacei, E. lanosum, Camissonia boothii, Eschscholzia minutiflora, Cryptantha spp. Pectocarya recurvata, Eriogonum trichopes, E. reniforme, E. maculatum, Chaenactis fremontii, C. carphoclinia, Erodium cicutarium and Lepidium lasciocarpum. Among the occasional species were Lupinus concinnus orcuttii, Amsinckia sp., Eriastrum sp., Astragalus didymocarpus didymocarpus, Gilia sp. Euphorbia micromera, Nama depressum, Linanthus schottii, Malacothrix sp., and Monoptilon belliodes.

Numerous old (old in 1977) 4-wheel vehicle impressions crossed the area. The depressed tracks and slightly raised centers were well vegetated with annuals which carpeted the flats other than the desert pavement; however, shrubs were less frequent on the tracks. One old road transecting the area had become a gully (< 30 cm deep) intermittently along one or both of the tire tracks. Two relatively recent 4-wheel tire tracks traversed the plot. Shotgun shells were common over the entire plot and litter from a recent campsite near the service road was scattered for about one quarter mile southward. I collected the litter and most of the shells. The telephone service road is ungraded and becomes a drainage channel during torrential rains. Erosion and deposition were evident and these probably obliterated indications of relative

use at other times of the year. I used the northeast end of the road primarily; the only other traffic was three automobiles--police inquiring of my welfare. Vegetation on the road was intermittently, relatively dense: Lotus tomentellus and Lupine were common there.

No cattle or their recent sign were seen on the site; however, faded cattle dung was abundant and faded burro dung, occasional.

There were 7 days with overcast cloud cover and light rain fell (usually for only minutes at a time) on 1, 2, 3, 23, 28, and 29 April and on 10 and 14 May; heavy rain fell on 29 April and 14 May. Winds estimated at more than 24 mph (Beaufort scale) blew during part of 11 days; during 4 of them speeds exceeded 40 mph for several hours.

METHODS

Subdividing Plot and Mapping

During the initial hours on the site the reinforcing steel rods placed in the NE, NW, and SW corners in 1977 were located. The 45 cm^2 flags glued to each during 1977 and furled at the end of my stay were still attached to two of the rods. At the SE corner a 2.5 m pole was lashed to the appropriate fence post and a bright red flag $\approx$ 2 feet square was attached. This could be seen from any point on the study plot. During part of the first 4 days the perimeter and quarter-section divisions were flagged every 50 meters with surveyor's tape tied to shrubs. The flagpole and boundary tapes were removed before I left the site.

The coordinates of any point on the site could be described in relation to the numbered poles and cardinal directions using a Brunton pocket transit. Features of distant mountains were helpful for maintaining heading

as I walked. Fractional divisions of the spaces between the poles were used as well as the poles themselves. Two coordinates were sufficient to plot or relocate the positions of tortoises, remains, and topographic features with relative precision ($\pm$ 25 m). The mapping of specific coordinates was done on ¼ inch quadrille paper on which the location of each telephone pole was plotted. The scale was 1 inch: 100 m (poles are 39.5 m apart).

Search Pattern for Locating Tortoises

The search pattern involved working successive days in a different quarter-section. I was camped on the side of the road near the section center, thus walking to and from the camper to a particular quarter-section resulted in the least number of access paths along which observations would be unequally concentrated. I walked headings of north/south and east/west using the poles and visual divisions of the spaces between them to maintain the heading of traverses. In addition, I walked the banks and beds of all major washes and most of the smaller drainage channels. Coverage overall was at least equal to traverses across the plot at 8 meter intervals in two directions at right angles to one another.

Morning search usually began before tortoises emerged from cover and continued until most tortoises were again in cover ($\approx$4-6 hours). Afternoon observations followed the same pattern. Actual times and durations varied with the weather. For part of each day and particularly on days with overcast and broken cloud cover, I searched for tortoises $\leq$ 60 mm long.

All tortoise burrows, kit fox burrow complexes and rodent burrow complexes were inspected for tortoises. Any tortoise seen on the site and most seen off the site were checked for having been marked. After the appropriate procedures were carried out with tortoises or any other event that took me off the heading of the traverse I returned to it and continued.

Capture Procedures

Upon initial capture of marked and unmarked tortoises a data sheet was filled out for each individual (See Appendix A for sample sheet and key). When a tortoise was sighted, I paced the distance to it. The micro habitat and the tortoise's behavior at the time of capture were recorded. Tortoise behavior during the procedures that followed was noted if other than remaining still. If the tortoise was feeding, the plant species was noted or the plant collected for later identification. The tortoise was placed on an 8" pie tin to collect bladder contents that might be passed during handling.

Shell dimensions were measured usually to the nearest mm with vernier beam calipers. Small beam calipers with 0.1 mm divisions were used to measure tortoises ≤ 95 mm carapace length. With the large calipers pre-field tests of accuracy and precision were performed, measuring a ruler (50 times) and 5 tortoises of various sizes (10 times each). The combined error of the calipers (95% confidence limit) was $\pm$ 0.7 mm.

In the field carapace length and various widths were measured. Plastral notch length was measured from the anal notch to the point on the gular where a space became evident between the forks.

Height of the shell was the greatest height. Using beam calipers eliminated error due to curvature of the plastron and depressed scutes of the carapace. Greatest height usually occurred at some point on the third vertebral (central) scute.

Unless otherwise stated, future reference to tortoise size means carapace length. Beginning in May, I remeasured many individuals again for growth (carapace lengths only).

Tortoises >175 g were weighed with the pan placed on a square cloth

sling of known weight, except for most large males that seldom voided during procedures the pan was kept under the tortoise. The total weight including voided urine was read to the nearest 25 grams on a Chatillon spring scale (6 kg capacity with 50 g divisions). Smaller tortoises were weighed to the nearest gram on a Pesola spring scale of either 300 or 100 g capacity with 2 and 1 g divisions respectively. A 14-g sling was used for most tortoises < 100 mm.

With a minimum of handling to reduce the likelihood of voiding, the tortoise was examined for injuries, anomalies, and parasites. Parasites--soft ticks--were removed and killed. Most shell injuries and anomalies were sketched on a diagram of the shell on the individual's data sheet. Marked tortoises that had been juveniles at last capture and unmarked tortoises were photographed; one photo of full dorsal view and a second of left costal 4 (for growth ring detail).

Unmarked tortoises were assigned an accession number and marked by notches in the marginal scutes that corresponded to a standardized number system adopted by the Desert Tortoise Council (See Appendix B for list of numbers used and available). Bridge scutes as well as free marginals are used; however for small tortoises with incompletely ossified and soft shells only numbers involving free marginals were used. Notches were made with a triangular file (nail clippers for very small tortoises), "V" shaped on the free marginals, linear grooves on the bridge scutes. The filing usually involved the scute material only. Each notch was lined with quick-drying yellow, acrylic pigment. Upon recapture, the paint greatly facilitated locating any grooved markings on the bridges. If the tortoise was out of reach in a burrow, painted notches were often visible (if present) and therefore the marked or unmarked status could be determined.

If unmarked, I sometimes was able to dab yellow paint on the exposed part and on a subsequent recapture identify the individual and utilize various information recorded when the "unidentified" tortoise was last sighted. The paint persists on most individuals for more than three years.

The liquid urine collected in the pan was drawn up into a 20 cc syringe and measured to the nearest cc. and the color described. The amount of insoluable salts was estimated. Urine voided during plastral measurements was not usually measurable because it ran over the shell and hind limbs; also some tortoises voided before they were touched.

After the initial capture of the spring, recapture data included the following: date, hour, temperatures, and other weather data, distance sighted, and behavior. Later the distance from last capture was written in when derived from mapped coordinates. These data were put on the individual's data sheet.

In 1977 I epoxied 6x15 mm paper tags with the tortoise's number, on a carapace scute that appeared to receive relatively little wear. The location and legibility of a tag or that of the number written directly on the shell and covered with epoxy was noted on the individual's data sheet.

The success of this marking method is being evaluated.

Coversites--pallets and burrows--used by an identified individual were measured:length, width at the base of the opening, greatest height of the opening, and soil depth over the opening. Also noted was the location relative to shrub cover and the species involved, the facing direction of the opening as 1 of the 8 cardinal directions, and the tortoise's position and location within the coversite. If the length could not be measured because the tortoise was out of reach or if removal of the tortoise would probably cause collapse of the burrow or pallet, the coordinates were noted, a nearby shrub flagged, and the length was measured at another time. The coversite data were also included on the individual's data sheet.

Collecting Tortoise Remains

All skeletal remains of tortoises were collected. Orientation, microhabitat, condition, sex and various measurements were recorded in duplicate on shell data cardsfor the complete and more or less complete shells. Also, these were photographed in the position found. Following a find the area was searched within a radius of 5 to 15 m. If remains were found in or by a wash of any size, a more intense search was made up and down stream. Discontinuous remains found 15-25 or more meters apart were treated separately. The thickness of a soil layer inside the shell was measured or estimated. The soil was retained and later sifted for additional remains. The specimen and the two shell data cards were sealed in a plastic bag. Later away from the field, disarticulated shells were pieced together temporarily in order to take approximate shell measurements. If the shells were incomplete, lengths were estimated by comparing available parts with those of articulated shells of known length. Signs of old injuries and those which may have been the cause of death were sought and noted.

Coyote scats were collected and examined for tortoise remains; if negative, they were discarded. The areas around active kit fox dens were periodically searched for tortoise remains. Tortoise egg shell fragments were collected and the inner surfaces examined for erosion typical of hatched eggs. The number of eggs represented was estimated. The site was described and if appropriate the soil was searched to 10-15 cm deep for additional fragments and indications of a nest site.

Vegetation Analysis

At least 1 permanent belt transect 100 x 2 m was to be established. The site chosen for Belt Transect I appeared to have a homogeneous plant

assemblage representative of most of the study plot vegetation in composition, density, and cover values of perennials and annuals, and also in soil surface characteristics. Each corner of the transect was marked by a steel reinforcing bar 1/2 or 3/8 inch diameter and $\approx$ 1.4 m long pounded into the ground for about two thirds of its length. The belt was temporarily divided into 50, 2 x 2 m quadrats. The frequency, density and canopy volume of perennials were recorded. Canopy volume was calculated for each perennial according to the following equation: $V = \pi\left(\frac{D_1 D_2}{4}\right)h$ where V is the plant volume, D_1 and D_2 the major and minor axes of the greatest elliptical cross section (of the canopy) parallel to the ground, and h, the plant height. Plants of the same species with overlapping canopies or discrete bunches of grass (Hilaria) were measured as one individual. Clone members (Larrea, for example) were measured as individuals if canopy was unshared. If the canopies of two plants of different species were intermixed completely the total volume was calculated and the species of the plant contributing the most to the canopy was credited.

Annual vegetation was sampled in a 20 x 50 cm area in the corner of alternate 2 x 2 m quadrats (25) by visually estimating the cover and frequency of each species within each 100 cm^2 quadrat. This was done on 10 April, 3 May and 3 June.

The decision to establish a second belt transect was made in May after considerable entitation. Permanent Belt Transect II was located at the north edge of the southeast quarter of the section in an area between parallel washes where most vegetation differed from the area west of the wash complex in density and composition of annuals and perennials. The SE 1/4 was itself varied but the area of Belt Transect II was representative of a large portion of it. Because the decision came late in May quantitative data is from perennials only.

The differences between various groups of data were tested for significance at the 5% level.

RESULTS AND DISCUSSION

Recapture Success, Population Structure, and Density Estimates

Of the 125 tortoises marked during 1977 and the 24 newly marked or included in 1978, 96 (64.4%) were recaptured in 1980. The percentage of each 1977-78 size class recaptured is given in Table 1. The lower percentage of juveniles < 100 mm probably reflects the relatively poor visibility and lower survival rate of the group. Among subadults and adults the differences between males and females were not significant. The 12 subadults had become adults by 1980; the poorer recapture success of those adults that were subadults when marked than those that were adults suggests that more of the younger adults emigrate than do the older adults. The higher percentage of recaptures of those that were Immatures compared to those that were Subadults may reflect the difference in their mobility, i.e., Immatures probably have smaller home ranges.

To date, 350 tortoises have been marked on the study plot. The population structure and sex ratios of tortoises marked in 1977 and 1978 and recaptured in 1980, and of tortoises marked in 1980 are given in Table 2. (See Appendix C for a list of tortoises marked outside the plot in 1977 and the dates when recaptured on the plot--included in the population.) A comparison between percent composition of each size class of tortoises marked in 1977-78 and all tortoises encountered during 1980 shows a considerable reduction in the percent of Subadults and an increase in the percent of Immatures and Very-young tortoises. Year to year fluctuations might be

expected as a result of variable reproductive and survival rates that are probably influenced by the availability of spring forage. Also, the rate at which tortoises move up through the size classes may affect the relative percentages. The Immature size class has twice the size range of Very-young and almost three times the range of Subadult, so that even if juveniles grew at the same rate the Immature class would tend to have more individuals than the other non-adult classes at a given time. The numbers in the Very-young and "Hatchling" classes are too low in 1977-78 to be responsible for the increases observed in the classes above them in 1980. This unequal representation reflects the difficulty in finding smaller individuals. I am assuming that most of the 20 Very-young tortoises marked in 1980 were on the study plot in 1977 or 1978 or had yet to hatch.

Table 1. Tortoises marked during 1977-78 and the number and percent of individuals that were in those size classes (regardless of present size) that were recaptured in 1980

Size class: carapace length (mm)	Total marked 1977-78	Total recaptured in 1980	Percent recaptured (of each size class)	
Adult ≥ 208	M 47 F 36*	38 29	80.8 80.6	80.7
Subadult 180 - 207	M 13 F 15	5 7	38.5 46.7	42.9
Immature 100 - 179	31	M 8 F 8		51.6
Very young 60 - 99	3	1		33.3
"Hatchling" <60	4			
	149	96		

*Includes 5 females 193-205 that were considered to be adults.

Table 2. Size classes and sex ratios of marked and recaptured tortoises--1977-78 and 1980

Size class carapace length (mm)	Total marked 1977-78*	Relative %	Recaptured in 1980 of 77-78 marked	Marked in 1980**	Total observed in 1980	Total observed in 1980 relative %
Adult $\geq 208^{\dagger}$	83	55.7	85	76	161	54.2
Subadult 180-207	28	18.8	6	20	26	8.8
Juvenile:						
Immature 100-179	31	20.8	5	79	84	28.3
Very-young 60-99	3	2.0		20	20	6.7
"Hatchling" < 60	4	2.7		6	6	2.0
	149	100.0	96	201	297	100.0
Number and ratio males:females						
Adult	47:36 (1.3:1)		$47:38^{\dagger\dagger}$ (1.2:1)	49:27 (1.8:1)	96:65 (1.5:1)	
Subadult	13:15 (.9:1)		3:3 (1:1)	14:6 (2.3:1)	17:9 (1.9:1)	
Subadults and Adults	60:51 (1.2:1)		50:41 (1.2:1)	63:33 (1.9:1)	113:74 (1.5:1)	
Adult : Non-adult	83:66 (1.3:1)		85:11 (7.7:1)	76:125 (0.6:1)	161:136 (1.2:1)	

Adult lengths (mean ± 1 SE)

Males: 251 ± 2.2 mm (208-307)

Females: 217 ± 1.3 mm (193-247)

*Includes 22 tortoises marked in 1978 and 2, marked outside the plot in 1977 but not captured on the plot until 1978 at which time they could be included.

**Includes 2 adults marked outside the plot in 1977 but not captured on the plot until 1980 at which time they were included.

†Includes 8 females 193-205 mm considered to be adults on the basis of anomalous carapace scutes that result in "short" carapace lengths and/or heavy shell wear, and/or growth rate ≤ 1 mm/year.

††The larger number of adult females recaptured than marked in 1977-78 is the result of recruitment from marked tortoises in other size classes (See Table

Population density estimates. Using the Lincoln Index with M as the number of tortoises marked during 1977-78 (the marking period)--149; n as the number of individuals encountered during 1980 (the sampling period)--297; and m as the number of tortoises within n that had been marked in 1977-78--96, the population estimate was 460 with 95% confidence limits of 382 and 538.

The Stratified Lincoln Index estimates a density for the population as a whole and for each size class. This method includes adjustments for those individuals that move into other size classes between the marking and recapturing. For the study plot population as a whole the N was 517 with 95% confidence limits of 422 and 634. The advantage of being able to project densities for juveniles--tortoises <180 mm-- was lost because only 1 of the 38 marked juveniles was recaptured in 1980.

Applying the Lincoln Index to successive, equal periods of mark and recapture and a cumulative M, and considering all tortoises as unmarked at initial capture in 1980, the N ± 2 SE for each period shows a continuing trend of increase (Table 3). No leveling off is apparent. This may be due to inadequate duration of the total sampling period; however, immigration, particularly if temporary, may be responsible.

When a transient tortoise or one whose home range lies mainly outside the study plot enters and is marked, subsequent population estimates, size class compositions and possibly sex ratios are permanently affected; however, the temporary absence of a marked tortoise whose home range lies primarily on the study plot has minimal effects on such estimates. Transient tortoises entering the study plot continue to add to the number of marked tortoises whether they are recaptured or not. The Jolly and Seber method (Cormack, 1972) attempts to compensate for emigration and immigration. From values derived

from successive, equal periods of mark and recapture during 1980 the mean population estimate was 251. No formula was available in the source used from which to derive confidence limits. Unlike the Lincoln N for the successive periods, the individual periods (13) showed no trend of increasing values, merely fluctuations; the mean ± 1 SD was 250.5 ± 41.8.

Table 3. Population density estimates based upon mark and recapture (Lincoln Index)

Mark and recapture period 1980	M*	n	m	Lincoln N	Limits (± 2 SE) lower	upper
1. Mar 29-Apr 1	0	12	0			
2. A2 - 5	12	36	2	216	-180 to	612
3. A7 - 10	46	40	11	167	81 -	253
4. A11 - 14	75	42	18	175	113 -	237
5. A16 - 19	99	54	24	223	155 -	291
6. A20 - 24	129	58	30	249	185 -	313
7. A25 - 28	157	57	31	289	219 -	359
8. A29 - M4	183	48	26	338	248 -	428
9. M5 - 9	205	51	35	299	243 -	355
10. M10 - 13	221	51	38	297	249 -	345
11. M14 - 18	234	47	35	314	260 -	368
12. M19 - 22	246	51	41	306	264 -	348
13. M27 - 30	256	52	44	303	267 -	339
14. M31 - J3	264	40	30	352	288 -	416
15. J4 - 7	274	42	31	371	303 -	439
16. J8 - 12	285 (297)	52	40	371	315 -	427

*All tortoises considered unmarked at initial capture in 1980.

As a possible indication of transient behavior I examined the size, sex, and location of each tortoise encountered only once during 1980. Of the 117, 12 were captured too close to the end of the marking period to have been encountered again. Of the 105 remaining, 66 (63%) were juveniles--much less apt to be seen again than subadults and adults. Of the 39 remaining, 18 (46%)

were within 100 m of the boundary. Ten of the 18 (56%) were marked in 1980, thirteen (73%) were males. Of the 21 remaining adults and subadults seen only once, 8 were females; 4 of them had been marked in 1977-78, 4 in 1980. Thirteen of the twenty-one were males, only 2 were marked in 1977, 11 (85%) were marked in 1980. Of the tortoises marked in 1977-78 that were recaptured in 1980, the percentage that were recaptured only once (16%) did not differ significantly from the percentage of tortoises marked in 1980 that were recaptured only once (26%). Of the individuals captured more than once during 1980, the difference between the mean number of recaptures of tortoises marked in 1977-78 and those marked in 1980 was not significant. The within-season recapture frequency and location are inconclusive indications of transient behavior during the short period evaluated.

Reproduction and Death (predation)

Egg loss due to predation was the only indication of reproduction (attempted) in 1980. Excavated nests with recently broken, empty egg shells were found on 2 June ($\approx$2 eggs represented) and 3 June ($\approx$3 eggs represented). In neither instance was the predator known. The locations of the nests are indicated in Figures 2A and B.

Potential or known predators observed directly or by sign on the study plot included: coyote, _Canis latrans_; kit fox, _Vulpes macrotis_; badger, _Taxidea taxus_; Bobcat, _Lynx rufus_; and roadrunner, _Geococcyx californianus_. No predation was directly observed. The 21 coyote scats examined were negative for tortoise remains.

Death was indicated by shell remains. There were 8 that were almost complete; a ninth was represented by the plastron only. Four of the nine appeared to have been exposed <1 year: 1 Immature, 2 Very young, and 1

"Hatchling." Tooth impressions and holes, and shell distortions suggested predation by carnivore as the likely cause of death. Three specimens may have been exposed for 1-2 years: 3 females--1 adult and 2 subadults; and 2 specimens for >2 years: an adult male and an adult female. Each of the 5 was disarticulated to some degree and all but one had impressions or holes apparently from predators' teeth. No identifying file marks were evident among the marginal scutes that were present.

In addition to the above remains there were eight groups with five or more shell elements and 26 groups with only one or two elements. The number of individuals represented by the 34 groups is not known. The locations of the nine shells are indicated on Figures 2A and B, and they are listed by number in Appendix I.

The difference between the number of shell remains found in 1977 (≈ 90) compared to the 1 found in 1978 (during 1 week) and the 9 found in 1980 is considerable. The first year in which systematic collecting was done was 1977 and most of the 90 shell were entire or almost complete. Either the shells at Goffs persist intact much longer than previously suspected, particularly in the presence of cattle, or there was a dramatic die-off within the two to three years prior to the 1977 collection.

Recapture Distances and Distribution

During 1980, 180 tortoises (61%) were encountered more than once (2-13). The interval between recaptures ranged from <24 hours (n=44) to 67 days. Of the 548 recaptures, 13 were successive at the same site (recapture distance =0). The recapture dates and distances between recaptures for each individual captured more than once during 1980 are given in Appendix D. Of the 535 distances (>0), the mean ($\pm$ 1 SE) and range, to the nearest meter, of each size class are as follows:

Adult males: 197 ± 10 (2-925) n=270 Adult females: 151 ± 13 (1-1225) n=151

Subadult males: 257 ± 35 (35-925) n=33 Subadult females: 172 ± 55 (7-900) n=21

Immatures: 82 ± 12 (6-675) n=55 Very young: 76 ± 33 (10-195) n=5

There were significant differences between the following pairs: male and female adults, male subadults and female adults, and between juveniles (both classes combined) and each of the other classes. Implied in these differences are corresponding differences in home range size. Home range sizes were not estimated because the area utilized in between recaptures was not known and I assume that a portion of the home range of many individuals recaptured on the study plot lies outside the study plot. Throughout a year the areas utilized and distances traveled by an individual may vary considerably. These are considerations that I feel are important based upon my findings from radio-tracking free-living tortoises in Nevada for periods greater than 1 year (Burge, 1977b).

Of the tortoises marked in 1977 and recaptured in 1978 and 1980, and those marked in 1978 and recaptured in 1980 the distances between recaptures over the intervening years can only be approximated because of the difficulty of transposing locations accurately among the rough, small-and-varied-scale maps available. With few exceptions the location of a tortoise at initial recapture in 1980 lay within the same quarter-section or within 200-400 m of the site where it was initially marked. Exceptions include the following: female # 506 initially marked ≈ 100 m beyond the study plot boundary in 1977, was recaptured inside the plot ≈ 1450 m from the last site. Male juvenile # 494 was ≈ 1300 m from the site where marked; and male # 441 was ≈ 1400 m from where last recaptured in 1978. Recapture distances > 400 m of tortoises marked in 1978 include: ≈ 600 m (Juv # 32) and 500 m (female # 16).

The means of the recapture distances in 1977 of adult males, adult

females, subadult males, subadult females, and juveniles 100-179 mm (n=54) were tested for significant differences with the means in 1980 for the corresponding size classes. The only significant difference was between the means of subadult males. The mean (± 1 SE) of 6 distances by subadult males in 1977 was 123 ± 60 m (10-35).

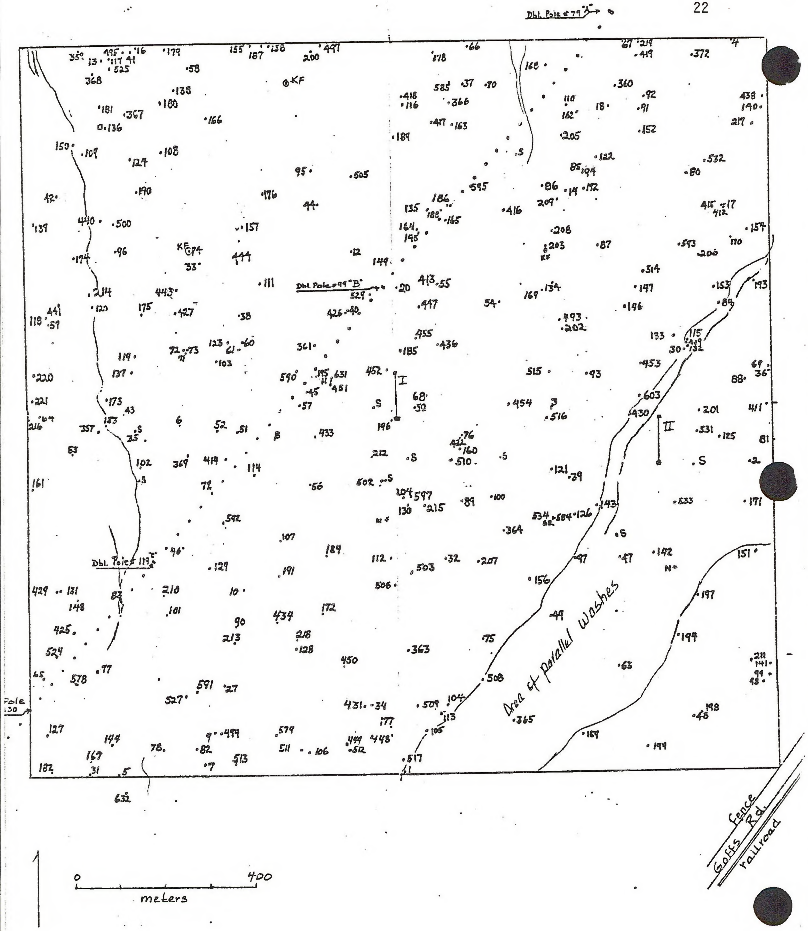
The capture-recapture locations of each tortoise encountered during 1980 have been plotted on one of five vellum overlays. These maps are part of the materials accompanying this report. The large scale (100 m/inch) and the individually plotted telephone poles should facilitate future use of these maps for year-to-year continuation of recapture distances and locations of each tortoise. The placement of a particular individual's recapture configuration on a given map was chosen for graphic clarity, not for biological reason. The location of each tortoise's configuration can be found by referring to the Map Number column or Index in Appendix D.

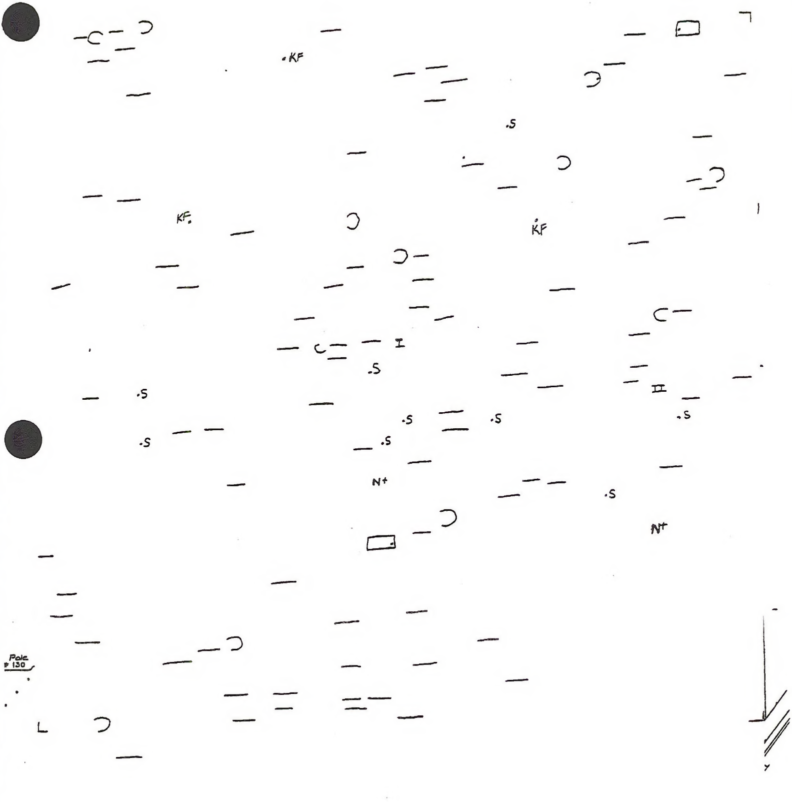
The initial capture locations of the 297 tortoises found on the study plot in 1980 are shown in Figures 2A and 2B. The locations of the three active kit fox dens are also indicated. The few capture sites between the dens in the northwest quarter suggested a possible relationship; however, when the locations of all the tortoises' capture and recapture points were examined the densities of capture-recapture sites within radii of 50, 100, 150 and 200 m of each den did not differ significantly from the mean density of the rest of the study plot.

Another area of apparent low density was that lying southeast of the southwest bank of the major wash complex--the southeast corner. This area comprises 47.5 ha, 17.8% of the study plot. The density of all capture-recapture locations in the southeast corner differed significantly from that of the rest of the study plot. One factor that may contribute to the difference is the proximity

Figure 2A. Initial capture locations in 1980 of tortoises marked during 1977, 1978, and 1980 (n=297). S = shell remains (9); N+ = recent nests excavated by predators (2); $\odot$ = active kit fox dens (3); (■———■) = permanent belt transects I and II. Telephone poles are spaced to scale.

Figure 2B. Figure 2A with overlay facilitates locating shell remains, nests, kit fox dens, plant transects and previously marked tortoises recaptured in 1980--(_____) = 84 marked in 1977, (⊃) = 12 marked in 1978, and (▭) = 2 marked outside the plot in 1977 and included in the population only when recaptured inside the plot in 1980.


Dbl. Pole #79 "A"
Dbl. Pole #99 "B"
Dbl. Pole #119 "C"
Pole 130
KF
I
II
Area of parallel washes
Fence
Goffs Rd.
railroad
0
400
meters


KF
S
N+
Pole # 130
L

of the southeast corner to Goffs Road and the potentially detrimental effects upon tortoises of vehicular traffic, directly and indirectly. Nicholson (1978) reported a high direct correlation between the increase in number of tortoises and distance from a paved road up to $\approx$ 1 kilometer. The southwest bank of the major wash parallels the road $\approx$ 650 m from it.

I submit the possibility that vegetation differences contribute substantially to the low tortoise density observed in the southeast corner. Lower perennial density over large areas and therefore fewer shrubs for cover (See Results: Belt Transect II) and the lower annual diversity, particularly the absence of LOTO, a principal forage species, are basic factors that should be considered.

The densities of capture-recapture locations within radii of 50, 100, 150, and 200 m of my camper were significantly greater than that of the area beyond the radii. Some or all of the difference was probably the result of a bias--the greater intensity of sampling that was unavoidable as I moved toward and away from the camper to the boundary of the quarter section to be sampled in a given day.

GROWTH

Growth of the current season was indicated if not measurable, by the presence of new scute material in the seams. Early in the spring or in older tortoises a hair-line width of light material may be all that is evident.

Of 297 tortoises encountered and examined on initial capture for new material in the seams or hair-line whitening, 37 were either captured only very early in the spring prior to growth or the condition was not appraised on a subsequent recapture.

<u>Growth of tortoises during 1980</u>. To consider 1) the incidence of growth and 2) the amount of growth within 1980, I grouped tortoises according to size class. Adult male sizes were divided into 2 groups at 247 mm. This facilitated comparing adult males with adult females--maximum length at Goffs was 247 mm.

The incidence of growth during 1980 was 100% among all juveniles ($<$180 mm) and males 180-207 mm; 97% of males 208-247 mm, and 59% of males $>$247 mm; 71% of females 180-207 mm and 70% of females 208-247 mm. The 29% of females 180-207 that showed no growth were those individuals that had previously been judged as adults on the basis of shell wear and/or carapace scute anomalies that resulted in "short" carapace length (195-205). If these smaller but adult females were placed with other adult females the incidence of growth of subadults females would be 100% and of adult females, 63%.

During the spring 1980, 114 tortoises were remeasured (carapace length), 13 of them 2 or more times. The interval between measurements ranged from 4 to 67 days, the mean ($\pm$ 1 SD) was 37.5 $\pm$ 16.5. Initial capture measurements were made between 29 March and 11 June; therefore, the amounts of growth represent intervals of different lengths at different times within the growing season. A comparison of growth rates within 1980 of 93 individuals that had measurable growth ($\geq$0.5 mm) and were measured at least twice was expressed as rate (mm) per day for the interval between measurements. For those individuals that showed a cessation of growth, the average for the period(s) in which growth occurred was used. Remeasured tortoises are listed by number in Appendix E and by carapace length and sex in Appendix F. Total amounts of increase in carapace length for the partial season ranged from 0.5 to 15 mm. The highest rate was 0.45 mm/day:J # 157 who was 150 mm at initial capture

grew 22 mm in 10 days, J # 131 (147 mm) grew 6 mm in 18 days--a mean rate of 0.33 mm/day. The mean rate per day was tested for significant difference between pairs of size classes. There was no significant difference between juveniles <100 mm and those ≥ 100 mm, and their values were combined. Differences were significant between juveniles and adult females and each group of adult males. Also, between subadult males and each of the three adult groups. Tortoises marked in 1980 are listed with their complete measurements in Appendix G.

Growth between 1977 and 1980. Growth between initial captures over the past three years was examined for the 86 tortoises that were marked in 1977 and recaptured during 1980 and over the past two years for the 12 tortoises marked in 1978 that were recaptured in 1980. Tortoises are listed by number in Appendix E and size and sex in Appendix H. Negative values (to be discussed) were considered as no growth. Considering caliper precision ($\pm \approx 1$ mm) the incidence of growth was considered only for those tortoises that showed an increase in carapace length of >1 mm over the past two or three years. Individuals were grouped according to their size class when marked. The incidence of growth (percent of each size class) was 100% for juveniles and for males that were ≤ 247 mm; 60% of males > 247; 66% of females 180-207 mm; and 52% of females ≥ 208 mm. The 33% females, 180-207 mm, (subadult class) that grew ≤ 1 mm had been judged adults in 1977. Their adult status has been supported further by the additional criterion of their reduced growth rate (at maturity). If these smaller adult females are included with adult females ≥ 208 mm then the incidence of growth among subadult females would be 100% and of adult females, 47%. The incidence of growth within 1980 and between 1977 and 1980 are similar for each size class or maturity level.

The greatest length increase (mean/yr) was 27 mm, female # 20 who was 151 mm at initial capture in 1978. Including individuals that averaged ≥ 1 mm/yr the mean per year ($\pm$ 1 SE) of each sex and size class (when marked) is listed below with the size ranges of the individuals involved. Adult females < 208 mm are included with those $\geq$208 mm:

Adult males (11) 247-273 2.5 ± 0.6

Adult males (19) 208-247 5.8 ± 0.6 Adult females (15) 193-225 1.1 ± 0.1

Subadult males (5) 180-207 12.5 ± 1.5 Subadult females (5) 180-206 5.9 ± 1.5

Juveniles (74-175) (17) 18.1 ± 1.2

The difference in mean length increase between various pairs of size classes were tested for significance. The difference between the means of 8 juvenile males and 8 juvenile females was not significant and their values were combined and that of the one unsexed juvenile added.

The only other difference in means that was <u>not</u> significant was between adult males 208-247 mm and subadult females. The order of decreasing growth rate is as follows: juveniles, subadult males, subadult females and adult males 208-247 mm, adult males > 247 mm, and adult females.

No adjustment was made for the fact that the entire growth periods within each year was not represented by most individuals, nor was the extent of a growing season known--12 June was the last day of the marking period in 1980. The beginning and ending dates are needed in order to project a total growth from a mean rate per day of part of the period. Medica, et al. (1975), during a 10 year study of tortoises in enclosures in Nevada, found very little evidence of growth after the first week of July. Burge (1977b) studying free-living tortoises in southern Nevada found that during 1975 growth continued through the end of July mainly among juveniles. Another variable that may have affected the mean growth per year observed at Goffs was different initial

capture dates in successive sampling years--marking periods have been from about 1 April through 12 June in 1977 and 1980 and 8-19 May in 1978. Over a short three-year period the affect of the measuring dates may be significant. For these reasons I have not attempted to compare growth rates between successive years. Medica, et al. (1975), reported greater increases in growth following winters with high precipitation and a correspondingly increased production of annuals in the spring. With the establishment of permanent belt transects at Goffs the above relationships should be quantifiable over a long period of observation. Forage availability in the spring of 1980 was considered very good. Any inequality in forage availability over the past three (or two) years has been smoothed by using the average growth per year.

On examination of the growth of the 19 tortoises marked in 1977 and remeasured in 1978 and in 1980 (Appendix H) a slight decrease in growth rate is evident in most individuals from the 77-78 measurement to the mean per year for 1978-80. This may have been due to less optimum forage conditions, or the tendency for growth rates to decrease as size increases or both.

The negative values observed in Appendices E, F, and H are probably due to one or more of the following: 1) The precision of the calipers used (± 0.7 mm) plus the effect of a difference in touch between investigators (in successive years). A combined error of ± 1 mm is probably an under estimate. 2) The flexibility of the posterior carapace particularly noticeable in females. I have observed and felt a reduction in tension between the caliper jaws during use, and seen a flexing by the tortoise in response to the touch of the calipers. The shell is not completely rigid in any case, and compression and release by the person measuring are difficult to avoid. 3) The development of a notch in the margin of the post vertebral scute could account for some apparent decrease in females that were no longer growing. The notch

is apparently the result of years of abrasion by the plastron of mounted males. Different degrees of flattening of the abraded area, which may involve part of V-5 as well as the post vertebral, are evident in most mature females. Noting the presence of a notch and measuring the extent of emargination at the time of carapace measurements would allow adjustment of the growth increment for the same interval.

Injuries, Parasites, Anomalies, and Unusual Shell Conditions

Injuries. Injuries were found on 25% of the tortoises marked in 1980 and on 48% of the previously marked tortoises recaptured in 1980. The difference in percent probably reflects the percentage of adults in the two groups: 37% in the former, 89% in the latter. Most injuries involved the shell and were either slight or the scars were now superficial, none were recent. All the old injuries visible on the tortoises could have been the result of predator attacks. For example, chipped and irregular edges of marginals (very common), gouges, pits in the scutes and nicks to the bone, and gular tips gone, edges irregular. Only two tortoises of those marked in 1980 appeared to have had relatively severe injuries: Subadult male # 94 had an old depressed fracture involving LM-8 and part of LC-3. Also affected were LC-1 and 2, the right abdominal scute, and the gular was truncated, edges irregular as if gnawed. In Juvenile # 197 the left hind leg from just below the knee was absent, a calloused stump remained and the tortoise walked with a teetering gait.

The nuchals of 10 mature females were gouged in the area of the posterior seam and V-1. That only females were affected was of interest. The gouges could have been made by predators' teeth but also possibly by the beaks of courting males as they nip at the anterior shell and forelegs of the females.

Forty-two percent of the tortoises marked in 1977 had signs of injury; thirty-three percent of those marked in 1978 (Nicholson, 1978).

Parasites. Soft ticks--Argasidae--(probably *Ornithodorus* sp.) were found on 16 subadult and adult males, 5 subadult and adult females, and 3 juveniles (141-169 mm), 8% of all the tortoises seen during 1980. Ticks were evident from 3 April through 11 June. Twelve of the tortoises had only one tick, twelve had 2 to 19 each. None of the ticks were feeding; most were at rest on the posterior marginals and seams, often under a film of soil. Several ticks were crawling over the carapaces. In 1977, 10% of the tortoises had visible ticks; in 1978, 13%.

Anomalies. Shell anomalies involving size, shape, and number of scutes were seen in 48 (24%) of the tortoises marked in 1980; 7 of the 48 had more than one type of anomaly. Some of the more common anomalies may have been post traumatic, e.g., distorted gulars and nuchals--seen on 10 males, 3 females and 1 juvenile; and false seams (not centers of scute growth) seen on 9 males and 2 juveniles. Some false seams were associated with partial forking of the nuchal or post vertebral scutes (Juvenile # 177 and Juvenile # 183). These may have been developmental anomalies. Partially cleft nuchals were observed on 4 tortoises. Supernumerary scutes (boardered by functional seams) were observed on 10 tortoises: 5 involved marginals--12 on one or both sides, 5 involved vertebrals and/or costals. Reduced number of scutes was seen on 3 tortoises--typically 10 marginals on one or both sides.

In 1977, 45 (31%) of the tortoises had anomalies of the kinds described above.

Unusual shell conditions. Chip-wear, whitening, and subsurface

vermiculations were apparent in tortoises seen during 1980. Chip-wear has been described in detail (Burge, 1977a). To my knowledge chip-wear is peculiar to tortoises at Goffs. The condition is unusual because of the depth of the craters that remain as a result of delamination--first, of the central portion of the scutes (the large carapace scutes in particular) and eventually, the entire upper layers. Elsewhere and in other tortoises at Goffs wear occurs in smaller increments. The other unusual aspect of chip-wear is its occurrence in juveniles in 1980, usually accompanied by a condition that appears to precede chipping--sub-surface air spaces apparently at the level at which the craters form. Forty-two percent of the Immatures and Very young tortoises evidenced chip-wear and or sub-surface air spaces; 29% of the adults. Of the marked tortoises from 1977-78, 27% of the adults were affected and the one 121 mm juvenile recaptured (# 450) had some chipping. In 1977, chip-wear was evident in 25% of the adult males and 44% of the adult females. The difference between the sexes in 1980 was negligible.

Whitening of the shell surface was seen on both carapace and plastron. The extent ranged from parts of several adjacent scutes to the entire shell. The general appearance was dull, white and frayed growth rings were also evident. Of the tortoise marked in 1980, 9% of the adults and subadults were affected and 9% of Immatures and Very young classes. In 1977, only two tortoises had whitening, one was recaptured in 1980 (female # 578), and no mention was made of the condition in the recapture notes. Two tortoises that were free of the condition in 1977 evidenced it in 1980, F # 434 (179 mm) and F # 497 (206 mm).

The weights and general appearance otherwise of those with chip-wear and/or whitening were comparable to tortoises of respective sizes not having the conditions. The whitening condition appears to have no correlation with size. Possibly a fungus is involved.

Vermiculations. Minute, dark lines in circles and vermiculations under the aereolar portion of the scutes were apparent in 10 (38%) of the juveniles marked in 1980: 83% of the Very young, 25% of the Immatures. These irregularities possibly of the bone surface may be more visible through the scutes of smaller tortoises and/or may disappear as the tortoise grows. Slight imperfections in the bone surface like those seen on a juvenile shell collected in 1977 (field # 9-Ap-977-3) may be responsible for the vermiculations and circles seen on live tortoises in 1980.

Behavior

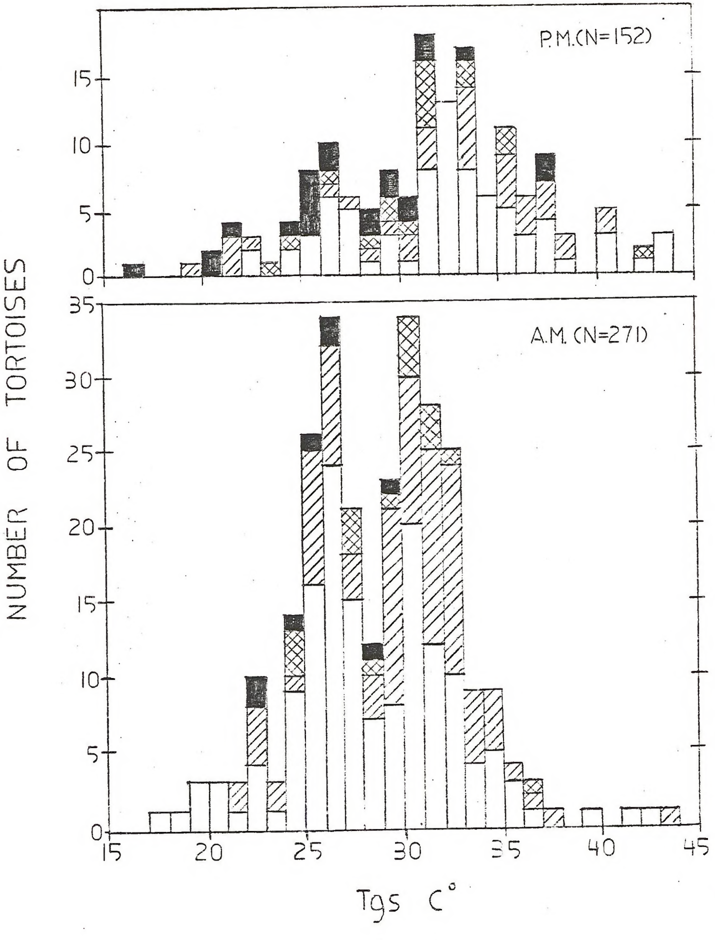
Activity in relation to Ground-Surface Temperatures (Tg_s). Activities analyzed in relation to Tg_s (C°) included: walking, feeding, courting, and digging. I did not include basking, emerging from or retreating to burrow cover, or resting in the shade of shrubs. Figure 3 shows the number of active tortoises and the temperature range in which activity was observed. The a.m. Tg_s mean ($\pm$ 1 SD) 28.5 $\pm$ 4.1 C (N = 276) differed significantly from the p.m. mean, 31.3 $\pm$ 5.4 (N = 152). The reason for the fewer number of active individuals in the a.m. between 27.0 and 29.9 is not known.

When the daily activity is considered over the spring as a whole the curve is bimodal--distinctly so under clear skies, increasingly less so with increasing cloud cover. The range of times at which active tortoises were seen was from 0615 (PST) through 1737. The effect of body temperature upon activity levels is implied in the shifts of time and duration of the bimodal periods under different degrees of cloud cover. When it was clear (<1/10 cloud cover) peak times of activity were between 0800 and 0830 and between 1600 and 1700 (N = 251). When cloud cover was scattered (1/10-5/10), 0830 - 0900 and 1430 - 1530 (N = 125); under broken cover (6/10-9/10) 0800 - 0930 and 1330 - 1430

Figure 3. Ground surface temperatures (Tgs) and number of active tortoises observed under various degrees of cloud cover through a.m. and p.m. observation periods from 29 March through 12 June 1980.

□ = clear (< 1/10), ▨ = scattered (1/10-5/10),

▩ = broken (6/10-9/10), ■ = overcast >9/10.


P.M.(N=152)
A.M. (N=271)
NUMBER OF TORTOISES
Tgs C°
0
5
10
15
20
25
30
35
40
45

(N = 30) and when overcast (> 9/10 cloud cover) 1300-1330 (n = 29). The lowest Tg_s when a tortoise was seen active, was 16.6--adult male # 361 was feeding in light rain at 1308, 14 May.

Although tortoises were active during days with momentary light showers there were only two observed occasions in which activity was apparently in response to actual or imminent rain.

Response to rain. During rain or when rain appeared imminent I checked areas of well developed desert pavement for depressions like those I had seen tortoises digging and from which I had seen them drinking during showers (Burge, 1977a). One or more depressions were evident on most stretches of desert pavement at Goffs. Tortoises also eat soil from these depressions or others like them (See geophagy). Depressions are characteristically pebble-free, circular to oval, 15-45 cm diameter; sloping to a depth of 2-6 cm at the center.

On 29 April, rain began at 0200; at 0230 (Tgs 9.0) there was no puddling in the depressions checked. At 0630 (Tgs 12.2) water was 5-8 mm deep in the depressions checked. At 0810 (Tgs 12.8) water was present in only one of the depressions checked and no tortoise use of any depressions was indicated. At 0830, rain ceased but cloud cover continued overcast to broken. At 1045 (Tgs 21.2) 5-10 cc remained in one depression. Four of the seven tortoises seen between 1045 and 1315 were basking. At 1300 (Tgs 24.2) rain began and continued intermittently until 1510 (Tgs 20.0) when rain became torrential and puddling was widespread; 1610 (Tgs 17.2); no tortoises had been seen since 1315 and none of the depressions indicated recent use. In 1977 tortoises were active during rain when Tgs was 13.4 and 14.0; however, prior to the shower there had been several hours in which Tgs was > 30.0 and

tortoises were active. On 29 April, 1980, because of the continued overcast and low temperatures during the morning, fewer tortoise emerged, even to bask; therefore few, if any, may have attained a body temperature, conducive to activity.

On 28 April, at 1015 (Tgs 22.8) female #96 was found resting on desert pavement with her head over a shallow depression. Light rain fell for 8 minutes and was insufficient to cause puddling. At 1107 #96 had turned 180° and was 4 m from the depression, walking away from it. On 10 May there was increasing cloudiness with gusting winds, 19-24 mph. At 1220, Tgs was 29.4; at 1245 (Tgs 21.2) rain appeared imminent, male # 440 was found on desert pavement in front of a depression; at 1255, light rain began; 1325, # 440 was in the same position, his head withdrawn half way under his carapace. At 1330 when the rain, which had been insufficient to cause puddling, stopped, # 440 was still in place. Apparently both tortoises were waiting for depressions to fill with rain water.

The rain on 14 May also produced no puddles, but it is interesting to note that the relative state of tortoises' hydration was improved, indicated by the color of urine voided during handling. With the exception of 23 instances between 2 May and 8 June the color of voided urine was either amber or pale amber. Between 2 and 15 May, 17 of the 23 instances of pale yellow or yellow urine were seen. The remaining 6 were between 20 May and 8 June. This suggests that additional water was utilized either from free standing water or via increased succulence of forage.

Coversite usage. The following information has been derived from the number of uses of burrows and pallets and the characteristics of those coversites. Repeated uses of given coversites were considered a more meaningful

measure than merely the total number of coversites used (and their characteristics). The term pallet as used here refers to a coversite that is no longer than the tortoise inside it.

Of 223 coversite usages observed, 37 involved juveniles, 47-179 mm, and 186, tortoises 180-307 mm. Rodent burrow complexes comprised 14% of the usages by juveniles and 6% of the usages by larger tortoises. Kit fox burrow complexes (abandoned or used occasionally by kit foxes) comprised 8% of the usages by adults and subadults. Kit fox burrow complexes were often used by more than one tortoise at a time. Five burrows were found in more or less vertical wash banks.

Of the 186 coversite usages of tortoises ≥180 mm, 150 (81%) involved coversites under shrubs. Of the 37 juvenile usages, 29 (78%) were of coversites under shrubs. For the two size groups combined, shrubs were associated with 75% of the burrow usages and 92% of the pallet usages.

The approximate, relative percentages of shrub species usages for the two size groups of tortoises are as follows:

Tortoises ≥180 mm		Tortoises < 180 mm
51	*Larrea tridentata*	45
22	*Ambrosia dumosa*	38
8	*Opuntia echinocarpa*	3
8	*O. ramosissima*	
4	*O. stanlyi parishii*	
3	*Hilaria rigida*	3
1	*Krameria parvifolia*	10
1	*Acacia greggii*	
< 1	*Lycium* sp.	
< 1	*Echinocactus polycephalus*	
< 100		99

Juveniles used relatively more Ambrosia and Krameria than larger tortoises. The relatively small, low but dense cover provided by the two species in contrast to the more open habit of Larrea is probably the reason. Juvenile burrows are more difficult to see. On more than one occasion the opening and apron of excavated soil were completely concealed by the unbroken canopy of Ambrosia or Krameria. Both size groups showed a preference for Larrea, even greater than that indicated by the values above if usage is examined relative to the relative frequency and density of shrub species on the study plot. The vegetation on belt transect I typified the study plot vegetation. The relative frequency of Larrea on the transect was 8%; relative density, 4%; whereas, the respective values of Ambrosia were 61% and 62% (See Tables 5 and 6). One advantage of using the Larrea would be the larger total area of shade provided. The apparently higher percentage of use of Larrea by juveniles may be the result of a bias--juvenile burrows under Larrea were much easier to see.

The facing directions of coversites used during 217 observations were tested against a random orientation for each of the following groups: burrows under shrubs, exposed burrows, and pallets (94% were under shrubs). Differences found to be significant were: a greater number of exposed burrows facing east, a greater number of burrows under shrubs facing south, and a greater number of pallets facing south and west. Pallets facing northeast and southeast, and burrows under shrubs facing northwest were significantly less than expected. A thermal relationship is implied by facing directions and presence or absence of shrub cover but from these limited data I find no satisfactory explanations that are consistant with all the significant differences observed.

It is generally accepted that there is an important relationship between the thermal needs of tortoises and their behavior--choice of various microhabitats: daily and seasonally. The length (depth) of a coversite is among the choices.

To determine if there was a significant difference among the lengths of coversites used for each half of the spring, I considered only coversites used by subadults and adults. The relatively smaller lengths used by juveniles would have biased the results if included and the sample size of juvenile coversite usages was too small to be tested with reliability. Subadult and adult coversite lengths were placed in one of three groups--those ≥100 cm long, 30-99 cm long, and <30 cm long. From 29 March through 30 April the number of coversite usages among the three length groups did not differ significantly from the lengths used from 1 May through 12 June (Table 4).

Table 4. Number of coversite usages of 3 length groups by adults and subadults during each half of the mark and recapture period, Spring, 1980

	<30 cm	30-99 cm	≥100 cm	Total
29 March - 30 April	38	37	8	83
1 May - 12 June	37	46	16	99

Because only a fraction of the total number of available coversites were used during the spring and because tortoises dig coversites if they are needed, I assumed that the preferred lengths were equally available, actually or potentially, at any given time. The number of coversite usages of each length group were tested against an equal distribution for the period 29 March through 30 April and for the period 1 May through 12 June. In each period,

the fewer than expected uses of burrows $\geq$100 cm was significant and in the May-June period, the greater than expected uses of burrows 30-99 cm was significant. In the latter length group, the mean length of burrows used during the first period, 54 $\pm$ 19 cm (30-90) did not differ significantly from the mean length of that length group used during the second period, 49 $\pm$ 16 cm (30-80).

The mean length ($\pm$ 1 SD) of 24 burrows used by tortoises 100-179 mm was 43 $\pm$ 20 cm (10-80); of 9 burrows used by tortoises 60-99 mm, 17 $\pm$ 6 cm (10-30). Two burrows used by 2 tortoises < 60 mm, were 15 and 12 cm.

During my stay at the site, the shape of the anterior portion of two known burrows used by juveniles were changed, apparently by jackrabbit Lepus californicus which were sometimes seen at rest just inside a tortoise burrow or pallet. One burrow was completely excavated, probably by kit fox or coyote. Several shallow burrows and pallets collapsed from rain-soaked soil, these were not reopened during my stay at the site.

Coversites were used on different occasions by different individuals. Observations in the spring 1980 involved only adults and subadults. The following 6 burrows were used by one tortoise at a time and by the individuals listed:

1. F # 451, M # 11 (2 days), M # 56
2. F # 455, M # 56
3. M # 369, M # 11
4. F # 17, F # 532
5. Males # 62, # 584, # 534, F # 364
6. M # 84, M # 30

A shallow burrow used by J # 510 remained unused for $\approx$ 4 weeks and then was enlarged and used as a pallet by an unknown adult.

The shared use of coversites has been observed at the Arden study site in Nevada (Burge, 1978). There, 75% of the 11-25 coversites used repeatedly by an individual over a year or more, also were used by 1-5 other tortoises.

Courting and associated behavior. Behavior with reproductive implications included courting, simultaneous use of single-tortoise burrows by a male and female, pairs resting together, and depressions in the soil, sign resulting from attempted or actual copulation. Courting pairs were rarely observed for the entire duration of the interaction. Only one pair was seen before the tortoises became aware of one another's presence (M # 34 and F # 591, 8 June). Sometimes courting was implied by a pair at rest, centimeters apart, the female's costals and posterior vertebrals grey with fine recent abrasions presumably made by the plastron of the male when mounted. There were 20 observations of interactions or sign related to courting seen between 2 April and 8 June: 5 in April, 13 in May, and 2 in June. They included 6 courting pairs, 4 at rest together in the open, 4 simultaneous uses of single-tortoise burrows, and 6 mating depressions. In 12 of the 14 interactions related to courting in which the female was identified she was one that had been previously marked in 1977 or 1978. The fraction of females marked in 1977-78 observed in courting behavior was significantly greater than that of females marked in 1980; corresponding fractions of males showed no significant difference.

Agonistic behavior. A bout between males # 367 and # 500 was the only agonistic behavior observed. Male # 367, the apparent agressor, was an old tortoise, his shell plates were depressed and he had grown ≤ 1 mm in the past three years; whereas # 500 was a young adult, carapace scutes were not depressed, wear was moderate, and he grew 12 mm during the past 3 years. When I first saw the pair, they had already seen me and remained motionless for the next 3 minutes as I crouched $\approx$ 20 m away. Male # 500 was on his carapace at the top of a burrow apron, # 367 was closer to the burrow, facing the apron and a few centimeters from # 500's side. Male # 500 had voided urine and insoluable salts which

puddled on his plastron and ran down the sides of his shell. After 3 minutes, it appeared that the tortoises' response to me was delaying their responses to one another and I decided to confirm their identities and right the overturned tortoise (Tgs 29.4). I returned to near my initial place and crouched behind a shrub. After another 2 minutes in which neither tortoise moved, I left the site.

In 1980 all of # 500's 8 recaptures were within $\approx$ 100 m of the interaction site; # 367 was recaptured 8 times at points 155 to 285 m north of the site. In 1977, both were captured within $\approx$ 200 m of the site. I presume that the interaction was one of maintaining a dominance hierarchy or of territoriality.

Feeding. Tortoises were observed foraging on 125 occasions; on 25 of them the tortoise took a bite or two each few steps and continued to walk. At the distance that I first saw the tortoise it was not possible to determine the species of the food plant (invariably low and presumably annual) and locating the remains of the nibbled plants was considered impractical after a few attempts. The following list includes the food species and the number of observed occasions in which each species was eaten. Unless stated otherwise plant parts eaten included stems, leaves, and flowers.

72	*Lotus tomentellus* (1 dry)	LOTO
6	*Lupinus concinnus orcuttii*	LUCO
5	*Schismus barbatus*	SCBA
4	*Pectocarya recurvata*	PERE
1	*Pectocarya* sp	
1	*Pectocarya* or *Cryptantha*	
2	*Cryptantha micrantha*	CRMI
2	*C. angustifolia*	CRAN

2	Camissonia boothii (basal lvs)	CABO
2	Opuntia ramosissima (stem tips)	OPRA
1	O. basilaris (young pad)	OPBA
1	Euphorbia micromera	EUMI
1	Hilaria rigida (young shoots)	HIRI
100		

Dry plants were eaten on only 1 occasion (LOTO on 5 June). LOTO was abundant throughout the study plot west of the major wash complex. In the extreme SE corner Euphorbia micromera was common but was rare west of the major wash. Green LOTO was available through 12 June, however, noticeable drying was widespread on 1 June. By 8 June all or part of most plants were dry. A few scattered patches of green LOTO remained on the flats, and LOTO in the washes and on the service road were green through 12 June. The two occasions on which Cryptantha angustifolia was eaten were on 6 and 8 June. The two occasions on which OPRA were eaten were 10 and 11 June. The tortoises involved searched, then stretched to reach the spine-free tips.

On 12 May, Juvenile # 191 (92 mm) was found with a lizard scat in its mouth. The tortoise had picked the scat off the ground but had not taken a bite. The scat was dropped soon after I photographed the situation.

Geophagy. Tortoises were observed eating soil on 11 occasions (21 April - 8 June). Most feeding sites were of one of three types: 1) base of a vertical wash bank, 2) shallow depressions in well developed desert pavement, and 3) the slightly depressed surface of old, abandoned ant hill craters. The last two types are characterized by very fine soil. The 11 occasions are listed below and the sites described. The wash bank used by three observed tortoises this year was also used in 1977 (indicated on list by *). During

spring 1980 the surface of the base of the bank became somewhat sculptured in one place, apparently from a combination of traffic erosion--tortoises attempting to stand almost upright as they ate soil--and from the removal of eaten soil. A new hole developed horizontally in the base of the bank--6 cm long, the opening 4.5 cm wide, 6 cm high. Beak marks left by the eating tortoises were evident inside the hole as well as along 15-20 m of the bank.

21 April	M # 409	Vertical wash bank*
24 April	M # 117	Depression in desert pavement 35 x 20 x 1 cm
26 April	M # 129	Depression in desert pavement 45 x 25
4 May	J # 132	Vertical wash bank*
10 May	J # 190	Old ant hill 6 x 3.5 x 1
28 May	J # 108	Old ant hill 12 x 10 x 2
29 May	J # 199	Base of wash bank 10 x 5 x <1-1
30 May	J # 182	Old ant hill
31 May	M # 409	Vertical wash bank*
3 June	F # 425	Old depression on poorly developed desert pavement 35 x 20
8 June	J # 218	Near the base of a Larrea no special feature, appears to have just been dug by the juvenile, 3 x 2.5 x 0.5

In 1978, Nicholson collected soil samples from this bank and from 8 other sites--some where geophagy had been observed, e.g., desert pavement, and some at control sites. The results of the soil analyses reported (Nicholson, 1978) included concentrations (ppm), presumably of soluable saturation extracts, of calcium, magnesium, and potassium. At 7 of the 9 sites the range (ppm) for the respective minerals were 9-69, 21-35, and 1-5. At the particular bank where I observed repeated use, the values were 9, 18, and 1. Two remaining

sites 1 mile away had values of 225, 450, and 39; and 225, 1400, and 120; here Nicholson had observed geophagy or sign. Apparently even the sites of relatively low mineral concentrations are heavily used.

Vegetational Analysis

Permanent Belt transects I and II are oriented north/south. Transect I is slightly north of the center of the study plot, the northeast corner is 219 m south of telephone pole # 98. Transect II is in the southeast quarter and from it, north lies halfway between poles # 75 and # 76. At the north end of transect II west is in line with pole # 109; at the south end, west is halfway between poles # 112 and # 113. Transect locations are indicated on Figures 2A and B.

The values from analyses of perennials and annuals on transect I are given in Tables 5, 7, 8 and 9; values from perennials on transect II, in Table 6.

Table 5. Permanent belt transect I: Perennial vegetation, spring 1980

Species	Density #/ha	Relative density %	Volume cm^3/ha	Relative volume %	Frequency	Relative frequency %
AMDU	4300	62.3	$2.15(10)^8$	28.3	0.80	60.60
HIRI	1800	26.1	$1.23(10)^8$	16.2	0.20	15.15
LATR	250	3.6	$3.52(10)^8$	46.4	0.10	7.58
KRPA	250	3.6	$1.56(10)^7$	2.1	0.10	7.58
OPEC	150	2.2	$8.62(10)^6$	1.1	0.06	4.54
OPRA	150	2.2	$4.54(10)^7$	6.0	0.06	4.54
Total	6900	100.0	$7.59(10)^8$	100.1	1.32	99.99

Table 6. Permanent belt transect II: Perennial vegetation, spring 1980

Species	Density #/ha	Relative density %	Volume cm^3/ha	Relative volume %	Frequency	Relative frequency %
AMDU	1250	59.5	$9.74(10)^7$	14.3	.34	51.5
LATR	300	14.3	$3.02(10)^8$	44.4	.12	18.2
CAAR	300	14.3	$1.97(10)^8$	29.0	.10	15.2
HYSA	200	9.5	$8.37(10)^7$	12.3	.08	12.1
OPEC	50	2.4	--------*	----*	.02	3.0
Total	2100	100.0	$6.80(10)^8$	100.0	.66	100.0

*Canopy within LATR.

Table 7. Permanent belt transect I: Annual vegetation, 10 April 1980

Species	Cover cm^2/m^2	Relative cover %	Frequency	Relative frequency %
Schismus barbatus	2070	76.5	1.00	26.6
Lotus tomentellus	294	10.9	0.80	21.3
Small borages*	122	4.5	0.56	14.9
Lepidium lasciocarpum	67.2	2.5	0.24	6.4
Erodium cicutarium	48.1	1.8	0.24	6.4
Eriogonum sp	46.	1.7	0.28	7.4
Eriophyllum wallacei	23.6	0.9	0.20	5.3
Chaenactis sp**	21.2	0.8	0.12	3.2
Astragalus didymocarpus didymocarpus	12	0.4	0.04	1.1
Eschscholzia minutiflora	10	0.4	0.16	4.3
Camissonia boothii	1.6	< 0.1	0.08	2.1
Descurainia pinnata	0.8	< 0.1	0.04	1.1
Total	2704.4	100.0	3.76	100.1

*Includes Cryptantha micrantha and Pectocarya recurvata.

**C. fremontii and C. carphoclinia were present on and adjacent to the transect.

Table 8. Permanent belt transect I: Annual vegetation, 3 May 1980

Species	Cover cm^2/m^2	Relative cover %	Frequency	Relative frequency %
Schismus barbatus	1891.0	79.6	1.0	26.5
Lotus tomentellus	294.0	12.4	0.76	20.1
Cryptantha micrantha	9.4	0.4	0.20	5.3
Pectocarya recurvata	10.6	0.4	0.16	4.2
Lepidium lasciocarpum	38.1	1.6	0.28	7.4
Erodium cicutarium	50.0	2.1	0.16	4.2
Eriogonum sp.	37.5	1.6	0.44	11.6
Eriophyllum wallacei	1.3	< 0.1	0.08	2.1
Chaenactis sp.*	1.9	< 0.1	0.08	2.1
Astragalus didymocarpus didymocarpus	16.9	0.7	0.20	5.3
Eschscholzia minutiflora	16.9	0.7	0.24	6.4
Camissonia boothii	5.6	0.2	0.12	3.2
Descurainia pinnata	1.3	< 0.1	0.04	1.1
Total	2374.5	100.	3.78	99.5

*C. fremontii and C. carphoclinia were present on and adjacent to the transect.

Table 9. Permanent belt transect I: Annual vegetation, 3 June 1980

Species	Cover cm^2/m^2	Relative cover %	Frequency	Relative frequency %
Schismus barbatus	1428 (35)*	74.2	1.00	36.2
Lotus tomentellus	222 (66)	11.5	0.52	18.8
Eriogonum trichopes	95.6	5.0	0.12	4.4
Eschscholzia minutiflora	60.6 (5)	3.2	0.12	4.4
Lepidium lasciocarpum	56.3 (29)	2.9	0.32	11.6
Eriogonum sp**	32.5	1.7	0.36	13.0
Erodium cicutarium	20.6 (52)	1.1	0.12	4.4
Camissonia boothii	5.6	0.3	0.04	1.4
Pectocarya recurvata	2.5	0.1	0.04	1.4
Astragalus didymocarpus didymocarpus	1.3	<0.1	0.08	2.9
Descurainia pinnata	0.6	<0.1	0.04	1.4
Total	1925.6	100.2	2.76	99.9

*(%) composed of dry and almost entirely dry plants.

**Includes E. maculatum, E. reniforme, and some incomplete plants of undetermined species.

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Appendix A

Investigator's name

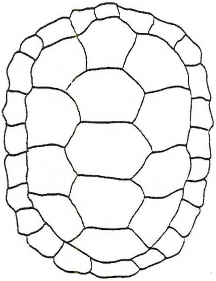
Gopherus agassizi

Site________
Co.________
___¼S___T___R___
Elev.________

No.________ Year marked: (if other than this date.)
Sex________
Date________
Time(PST)______

(shaded) T_a____(1m); ____(1cm); T_{gs}____
wind/cloud cover________

Behavior and microhabitat when found, Cover discription, Behavior during procedures unless merely remained still Distance at which sighted Continue on back
Location Relative to Telephone poles

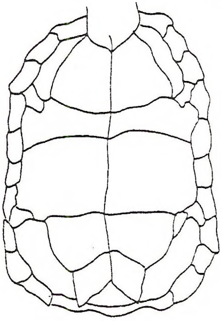


MCL____ ________
M3 (seam)________
M4 ________
7-8(seam)________
Gr W @________
Ht(mid central-3)____
Pl N________
Pl T________
Wt(g)________
minus Pan and/or sling wts. and calibration correction
adjusted________
Photo: Car.________
close-up________
other________
Gular cond. ok or discribe
[☆] Shell wear minimal, moderate, or heavy
Injuries 0 or discribed and/or draw

Anom. 0 or describe and draw

Parasites 0 or describe

New growth √ = present HL = hair line only
Voided √ or 0
During list procedures
Amount Collected + (indicate if lost)
Color Pale yellow to Amber or maroon
Insol. √ (present) and approx. amn't
Finish @ 00:00



Draw site of epoxied (1977) number. Legible?_____.
yellow paint in notches Visible?_____.

☆ (incomplete) attempt to classify wear according to D. Karl's System from available Photographs, after leaving the field.

Appendix B

List of accession numbers that have been used at the Goffs plot and those that are available as of the end of spring, 1980 (sequences are inclusive).

Tortoise numbers	Year used
1 - 10	1980
11 - 32	1978
33 - 221	1980
222 - 356	
357 - 375	1977
376 - 407	
408 - 455	1977
456 - 489	
490 - 535	1977
536 - 577	
578 - 604	1977
605 - 630	
631 - 639	1977
640 -	

Appendix C

List of tortoises marked in 1977 but found outside the study plot. Four have been recaptured on the study plot. At the time of first recapture on the study plot the tortoise can be included in the population, until then, consider the tortoise "unmarked".

Tortoise #	Date of first recapture
M 371	
M 372	2 April 1980
J 373	
F 421	
F 422	
F 424	
F 506	19 April 1980
M 520	11 May 1978
J 521	
M 522	
F 523	11 May 1978
J 526	
M 579	
M 580	
J 582	
M 586	
F 587	
M 602	
M 633	
J 634	
M 635	

Captures and recapture distances during 1980

tortoises marked during 1977

Tortoise #	Sex*	Date	Date	Dist. (M)	Date	Dist	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist	Date	Dist	** Map #
357	♂	5 Apr	11 Apr	150	16 Apr	325	20 Apr	475	5 May	230	7 May	650	12 May	525	14 May	225	30 May	460	3
			8 June	575															1
359	♂	9 Apr	28 May	235	10 June	35													1
360	♀	27 May																	1
361	♂	3 Apr	9 Apr	25	9 Apr	60	14 May	175	18 May	100									1
363	♀	19 Apr	1 May	25	2 May	9	6 May	135											1
364	♀	25 Apr	6 May	150	11 May	50	15 May	20											1
365	♂ SA	26 Apr	6 May	510	15 May	500													2
366	♀	4 May	28 May	200	31 May	30													5
367	♂	24 Apr	24 Apr	155	28 Apr	285	28 Apr	0	10 May	100	14 May	50	6 June	75	11 June	65			1
368	♂	18 Apr	24 Apr	125	28 Apr	150	6 June	90											1
369	♂	11 Apr	23 Apr	200	24 Apr	0	7 May	225	16 May	65	21 May	75							1
372	♂	2 Apr	21 Apr	275	13 May	250													1
409	♂	21 Apr	27 Apr	400	13 May	65	31 May	65	31 May	350									1
411	♀	18 May																	2
412	♂	7 Apr	22 May	25															1
413	♂	21 Apr	27 Apr	115	15 May	175	18 May	80	22 May	75	5 June	85							1
414	♀	16 Apr	20 Apr	225	26 Apr	150													1
415	♂	7 Apr	12 Apr	50	17 Apr	250	21 Apr	80	27 Apr	285	4 May	240	13 May	200	13 May	85	18 May	200	
			22 May	230															3
416	♂	17 Apr	21 Apr	100	13 May	225	31 May	200	9 June	100									1
417	♂	12 Apr	21 Apr	80	4 May	85	27 May	125	27 May	0	31 May	115							1
418	♂	21 Apr	18 May	75	28 May	85													1
419	♂	27 Apr																	4
425	♀	5 Apr	3 May	175	7 May	25	12 May	5	21 May	80	3 June	120	11 June	150					1
426	♀	3 Apr	18 Apr	180	28 Apr	40	5 May	35	6 June	85									1
427	♀	28 Apr																	1
429	♂	3 May	21 May	245	3 June	125													1
430	♀	21 Apr	11 May	510	29 May	125	2 June	610	5 June	75									1
431	♂	20 Apr	26 Apr	280	2 May	180	21 May	0	30 May	300									2
432	♀	11 May	11 May	10	15 May	15													1
(1) 433	♂	8 Apr	11 Apr	375	16 Apr	175	20 Apr	225	26 Apr	150	26 Apr	150	28 Apr	400	12 May	400			3
(179) 434	♀ J	3 June	8 June	145															1
436	♀	4 May	13 May	275	18 May	340	9 June	375											1
438	♂	2 Apr																	2
440	♂	10 May	6 June	85	10 June	150													1
441	♂	3 Apr	13 Apr	275	19 May	20	1 June	30											

(Continued)

Tortoise #	Sex	Date	Date	Dist. (M)	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Map #
443	♀	5 May	19 May	50															1
444	♀	13 Apr																	2
447	♂	8 Apr																	2
448	♂	26 Apr																	1
449	♂	16 Apr	19 Apr	80															2
(121) 450	J	3 May																	5
451	♀	3 Apr	5 Apr	75	8 Apr	75	12 Apr	0	18 Apr	50	19 Apr	50	26 Apr	100	27 Apr	20	28 Apr	125	3
			29 Apr	20	3 May	120													
452	♂	3 Apr	21 Apr	125	28 Apr	180	29 Apr	30	15 May	300									2
453	♀	4 May	20 May	230	2 June	110	7 June	175											4
454	♂	31 May	31 May	80															1
455	♀	4 May																	1
493	♂	27 May																	2
494	♂	11 Apr	7 May	185	12 May	150	16 May	25	8 June	85									1
495	♂	3 Apr	13 Apr	150	18 Apr	150	24 Apr	40											2
497	♀ SA	28 Apr	9 May	215															1
500	♂	13 Apr	13 Apr	75	13 Apr	50	24 Apr	100	10 May	85	10 May	130	14 May	50	28 May	80			1
502	♂	10 Apr	14 Apr	130	12 May	500	3 June	150											1
503	♂	14 Apr	20 Apr	250	27 Apr	700	16 May	710											1
505	♀	3 Apr	13 Apr	80	18 Apr	1	24 Apr	80	24 Apr	80	28 May	115	1 June	135	10 June	100			1
506	♀	19 Apr	16 May	150	11 June	660													1
508	♂	10 Apr	3 June	300															3
509	♀	6 May	15 May	325															2
(161) 510	♂? J	6 May	11 May	125															2
511	♀	16 Apr	7 May	65															3
512	♀	16 Apr	16 Apr	0	20 Apr	3	6 May	125	7 May	30	8 June	65							4
513	♂	5 Apr	8 June	100															1
514	♀	21 Apr	29 Apr	100															4
515	♀	28 Apr	18 May	90															4
516	♀	6 May	29 May	150															5
517	♂	19 Apr	19 Apr	125	25 Apr	225	11 May	300											3
524	♂	16 May	21 May	190	30 May	195													1
525	♂ SA	24 Apr	1 June	250															2
527	♀	11 Apr	7 May	100															1
(167) 529	♀? J	28 Apr	5 June	55															1
531	♀	4 Apr	8 Apr	600	14 Apr	20	20 May	75											5
532	[illegible]	17 Apr	27 Apr	75	8 May	50													2

(Continued)

Appendix D

Tortoise #	Sex	Date	Date	Dist. (M)	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	MAP #
533	♀	14Apr	25Apr	160	4May	100	11May	250	20May	125									1
534	♂	4Apr	2May	150	6May	75	29May	0											1
578	♀	8June																	1
579	♂	12May																	2
584	♂	10Apr	2May	7	2May	80	6May	50	29May	130	2June	150	2June	20					2
585	♂	21Apr																	5
590	♀	9Apr	13Apr	160	28Apr	150	14May	150											1
591	♀	12May	8June	5															3
592	♀	8Apr	11Apr	180	3May	60	12May	85	12May	75	2June	50							2
593	♀ 2A	21Apr	29Apr	20	13May	25	27May	75											3
595	♀	7Apr	17Apr	25	27Apr	250	4May	10	8May	150									1
597	♂	14Apr	19Apr	260	15May	75	29May	255	7June	175									4
603	♂	21Apr	4May	150	5June	450													1
(167) 631	♀? J	8Apr	18Apr	75	27Apr	50	27Apr	15	28Apr	80									2
632	♂	1Apr																	1
Tortoises marked during 1978																			
11	♂	4Apr	4Apr	125	4Apr	100	9Apr	125	13Apr	100	20Apr	25	26Apr	75	28Apr	125	5May	80	3
			7May	80	10May	0	19May	220											
12	♂	3Apr	3Apr	75	9Apr	150	24Apr	150	14May	115	9June	125							2
13	♀	14May																	3
14	♀	17Apr	22May	125															2
16	♀	18Apr	24Apr	0	24Apr	1	28Apr	10	10May	65									3
17	♀	7Apr	27Apr	20	13May	5	13May	20	31May	65									3
18	♀	8Apr	4May	425	8May	65	30May	200											2
20	♀ SA	24Apr	4May	75	8May	85	9May	7	13May	65	18May	75	19May	35	28May	65	5June	35	2
27	♂	11Apr	20Apr	75															2
30	♂	29Mar	4May	20	13May	150	18May	100	27May	80	5June	50	9June	15					2
31	♂	31Mar	1Apr	2	8Apr	75	20Apr	85	7May	30	21May	45	30May	75	8June	115			3
32	♂ SA	19Apr	6May	100	16May	475													

(Continued)

tortoises marked during 1980 -- only those recaptured

D (CL) Tortoise #	Sex	Capture date	Recap Date	Dist.	Date	Dist	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist	Date	Dist.	Date	Dist.	Map #
(151) 2	J	4 Apr	22 may	275															2
4	♀	30 Mar	22 May	30															2
5	♂	30 Mar	30 Mar	210															2
6	♂	30 Mar	18 Apr	200	21 May	100	3 June	330	3 June	65									5
7	♂	30 Mar	16 Apr	275	16 Apr	100													2
8	♀	31 Mar	5 Apr	130	8 Apr	120	13 Apr	450	18 Apr	275	18 Apr	75	20 Apr	60	7 May	150	12 May	8	2
			16 May	290	21 May	35	30 May	265	8 June	200	10 June	20							
(92) 10	J	11 Apr	26 Apr	20															2
33	♂? SA	9 Apr	28 May	85	9 June	120													4
34	♂	31 Mar	11 Apr	425	20 Apr	50	7 May	185	12 May	250	8 June	75							4
35	♀	31 Mar	5 Apr	160	30 May	50													5
36	♀	2 Apr	13 May	210	15 May	200	27 May	65											2
37	♀	2 Apr	8 Apr	100	4 May	250	22 May	180											2
(1??) 39	J	14 Apr	20 May	75	2 June	60	7 June	6											1
40	♂	2 Apr	3 Apr	15	3 Apr	125	19 Apr	575	24 Apr	950	10 May	175	18 May	475	1 June	275			5
41	♂	3 Apr	13 Apr	435	19 May	125	19 May	150											4'
42	♀	3 Apr	13 Apr	300	18 Apr	325	24 Apr	125	24 Apr	175									2
43	♀ SA	3 Apr	25 Apr	900	5 May	900	12 May	165											4
45	♀ SA	3 Apr	5 Apr	50	10 Apr	100	12 May	150	30 May	350	30 May	100							5
46	♂	3 Apr	8 Apr	140	10 Apr	550	20 Apr	600	3 May	100	3 May	65	12 May	225	3 June	210	8 June	65	2
47	♀	4 Apr	7 June	400															5
48	♀	4 Apr	10 Apr	525	14 Apr	325	19 Apr	480	16 May	175	3 June	125							4
49	♀	4 Apr	15 Apr	200															2
50	♂	4 Apr	8 Apr	135	9 Apr	175	10 Apr	400	14 Apr	75	2 May	250	7 May	250	20 may	200			5
51	♂	5 Apr	18 Apr	115	5 May	210	12 May	360	29 May	220	1 June	265							4
(151) 52	J	5 Apr	21 May	20															4
53	♂	5 Apr	16 May	115															4
54	♂	7 Apr	21 Apr	450	8 May	120	13 May	50	6 June	200									2
55	♂	8 Apr	17 Apr	275	5 May	50	5 May	225	5 June	240									4
56	♂	8 Apr	12 Apr	275	18 Apr	120	29 Apr	170	2 May	310	11 May	250	15 May	50	18 May	260	7 June	325	4
(162) 57	J	8 Apr	9 Apr	160	28 May	80	2 June	25	2 June	35	4 June	35	5 June	50	6 June	50			2
58	♀	9 Apr	19 May	125	28 May	85	6 June	70											5
(174) 59	J	9 Apr	30 May	575															2
60	♂	13 Apr	18 Apr	180	5 May	150	19 May	175	4 June	100	10 June	75							2
61	♂ SA	9 Apr	19 Apr	425															2
62	♂	10 Apr	12 Apr	225	25 Apr	110	27 Apr	175	13 May	50	18 May	90							3

(Continued)

tortoises marked during 1980 -- only those recaptured

Tortoise #	Sex	Capture date	Recaptures: Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist.	Map #
(164) 64	♂? J	11Apr	16Apr	25	3 may	125	14 May	200											2
(170) 65	♀? J	11Apr	26Apr	50	3 may	50													2
68	♂	12Apr	22 May	300															2
69	♂	12Apr	13 may	120	20 may	115	5 June	165											2
70	♂	12Apr	9 June	175															3
71	♀	9Apr	13Apr	150	1 June	240	10 June	185											3
(99) 72	J	9Apr	24Apr	75	30 May	195													5
74	♂	13Apr	13Apr	250	5 may	175	10 June	225											3
75	♂	14Apr	18Apr	975	19Apr	775	7 may	30	15 May	130	7 June	150							5
76	♂	14Apr	21Apr	225	21Apr	60	27Apr	175	11 may	150	11 May	10	13 May	420	13 May	125	20 may	600	3
77	♂ SA	16Apr	20Apr	75	26Apr	475	3 May	450	7 May	65	30 May	100	8 June	230					3
78	♀	16Apr	7 May	20															2
(172) 81	♂? J	1Apr	3Apr	0	4Apr	18	2 June	10	5 June	125									4
(109) 82	J	16Apr	20Apr	75	30 May	50													4
84	♂	17Apr	21Apr	120															5
85	♂	17Apr	21Apr	220	4 May	135	13 may	125	9 June	215									5
87	♀	17Apr	27Apr	185															4
(162) 88	♂? J	17Apr	27Apr	35	20 May	180	5 June	260											3
(124) 92	J	21Apr	27Apr	25	9 June	75													2
94	♂ SA	17Apr	4 May	215	13 may	180	27 May	35	31 May	100									3
96	♀	18Apr	24Apr	175	28Apr	155	28 May	125	10 June	55									4
97	♂	19Apr	25Apr	275	2 May	80	11 May	260	20 may	500									2
(70) 99	J	25Apr	26Apr	0	2 June	10													2
(165) 100	J	25Apr	20 May	150															4
(22) 101	J	26Apr	16 May	80	8 June	20													2
104	♂	19Apr	11 May	425	11 June	575													2
107	♀	20Apr	26Apr	200	16 May	150													2
(156) 108	J	28Apr	28 May	80	1 June	25	10 June	60											2
(62) 112	J	2 May	7 June	80															2
(145) 113	J	2 May	29 may	0	7 June	12													5
114	♂ SA	20Apr	12 May	260	21 May	50	8 June	140	8 June	50									4
115	♀	21Apr	29Apr	45															4
116	♂	21Apr	28Apr	250															2
117	♂	24Apr	6 June	50															4
119	♂ SA	24Apr	10 May	120	19 May	275													2
(141) 120	J	24Apr	6 June	30															2
123	♂ SA	24Apr	28 May	200	1 June	225	6 June	80											2

(continued)

Appendix D

Tortoise #	sex	Capture date	Recaptures: Date	Dist.	Date	Dist.	Date	Dist.	Date	Dist	Date	Dist	Date	Dist	Date	Dist.	Date	Dist.	Map #
126	♀	26 Apr	6 May	50	11 June	225													3
127	♀	26 Apr	7 May	180															2
129	♂	26 Apr	3 June	225															2
(126) 130	J	2 May	29 May	15															2
(147) 131	J	3 May	21 May	75															2
142	♀	2 May	20 May	35	2 June	50	7 June	250											4
143	♂	2 May	7 May	525															3
144	♂ SA	3 May	29 May	925	29 May	165	8 June	515											2
145	♂	4 May	4 May	110	8 May	55	9 June	175											2
146	♂	4 May	6 May	400	20 May	250	2 June	400											2
147	♂	4 May	13 May	15	27 May	75													2
149	♂ SA	8 May	19 May	325	29 May	550													3
150	♂	10 May	22 May	765	28 May	650	6 June	110											3
153	♀ SA	13 May	22 May	120															2
155	♀	14 May	6 June	150															2
(150) 157	J	19 May	10 June	20															2
160	♂	20 May	21 May	850															2
164	♀	22 May	30 May	1225	8 June	630													5
167	♂ SA	30 May	11 June	225															2
(141) 176	J	6 June	10 June	50															3
(113) 179	J	14 May	19 May	50															5
(139) 182	J	7 May	12 May	75	30 May	65													5
(177) 183	♂ J	7 May	14 May	115	19 May	115	6 June	100											5
(144) 188	J	9 May	5 June	40	9 June	0													3
(107) 190	J	10 May	28 May	50															5

* Adult unless otherwise noted -- SA, subadult; J, juvenile; ?, Sex uncertain

** See accompanying maps of plotted recapture locations; see complete list for tortoises marked in 1980

① Carapace length when marked (juveniles)

Appendix D

Index to accompanying maps of all recapture points of tortoises marked during spring 1980 (Goffs)

Tortoise #	Map #	Tortoise #	Map #	Tortoise #	Map #	Tortoise #	Map #
1 J	5	74 ♂	3	125 ♀	3	177 J	5
2 J	2	75 ♂	5	126 ♀	3	178 ♂	5
3 J	2	76 ♂	3	127 ♀	2	179 J	5
4 ♀	2	77 ♂	3	128 ♂	3	180 J	3
5 ♂	2	78 ♀	2	129 ♂	2	181 J	1
6 ♂	5	79 ♂	5	130 J	2	182 J	5
7 ♂	2	80 J	5	131 J	2	183 J	5
8 ♀	2	81 J	4	132 J	3	184 J	4
9 J	5	82 J	4	133 J	5	185 J	5
10 J	2	83 J	1	134 ♂	5	186 J	4
33 ♂	4	84 ♂	5	135 ♂	4	187 J	5
34 ♂	4	85 ♂	5	136 ♂	2	188 J	3
35 ♀	5	86 ♂	5	137 J	1	189 J	5
36 ♀	2	87 ♀	4	138 J	1	190 J	5
37 ♀	2	88 J	3	139 J	1	191 J	4
38 J	1	89 J	2	140 ♂	2	192 J	2
39 J	5	90 J	4	141 ♂	1	193 J	1
40 ♂	5	91 J	5	142 ♀	4	194 ♂	2
41 ♂	4	92 J	2	143 ♂	3	195 J	1
42 ♀	2	93 J	5	144 ♂	2	196 J	2
43 ♀	4	94 ♂	3	145	2	197 J	1
44 ♀	1	95 ♂	2	146 ♂	2	198 J	1
45 ♀	5	96 ♀	4	147 ♂	2	199 J	1
46 ♂	2	97 ♂	2	148 ♂	2	200 J	5
47 ♀	5	98 J	4	149 ♂	3	201 J	5
48 ♀	4	99 J	2	150 ♂	3	202 J	5
49 ♀	2	100 J	4	151 ♂	3	203 J	5
50 ♂	5	101 J	2	152 ♀	5	204 J	2
51 ♂	4	102 J	2	153 ♀	2	205 J	3
52 J	4	103 J	1	154 ♂	3	206 J	5
53 ♂	4	104 ♂	2	155 ♀	2	207 J	4
54 ♂	2	105 J	1	156 J	3	208 J	4
55 ♂	4	106 ♂	1	157 J	2	209 J	4
56 ♂	4	107 ♀	2	158 ♂	1	210 J	4
57 J	2	108 J	2	159 J	1	211 J	5
58 ♀	5	109 J	1	160 ♂	2	212 J	2
59 J	2	110 J	5	161 ♀	1	213 J	2
60 ♂	2	111 J	4	162 J	1	214 J	3
61 ♂	3	112 J	2	163 J	5	215 J	4
62 ♂	3	113 J	5	164 ♀	5	216 ♀	1
63 J	2	114 ♂	4	165 J	5	217 ♀	5
64 J	2	115 ♀	4	166 J	1	218 J	5
65 J	2	116 ♂	2	167 ♂	2	219 J	5
66 ♂	1	117 ♂	4	168 J	1	220 J	1
67 ♀	2	118 ♂	5	169 ♀	3	221 ♀	1
68 ♂	2	119 ♂	2	170 J	5		
69 ♂	2	120 J	2	171 J	5		
70 ♂	3	121 J	4	172 J	3		
71 ♀	3	122 J	3	174 ♀	1		
72 J	5	123 ♂	2	175 J	5		
73 J	1	124 ♂	3	176 J	3		

Growth: tortoises marked during 1977

Tortoise #	Sex	Capt 1977 (1)	CL (mm)	Capt 1978 (1)	Δ CL (+)	Capt 1980	CL	Δ CL (mm) 78-80	Δ CL (mm) 77-80	Remeas 1980	CL	Δ CL	# Days
357	♂	8 Apr	190			5 Apr	230		40	30 May	234.5	4.5	55
359	♂	8 Apr	213			9 Apr	237		24	28 May	238	1	49
360	♀	8 Apr	225			27 May	228		3				
361	♂	8 Apr	222	9 May	+16	3 Apr	250	12	28				
363	♀	9 Apr	219			19 Apr	222		3				
364	♀	9 Apr	233			25 Apr	233		0	11 May	234	1	16
365	♂J	9 Apr	145			26 Apr	193		48				
366	♀	9 Apr	216			4 May	220		4	28 May	220	0	24
367	♂	9 Apr	238			24 Apr	284		1	6 Jun	284	0	43
368	♂	9 Apr	228	9 May	+8	18 Apr	248	12	20	28 May	250	2	40
369	♂	9 Apr	241	12 May	+7	11 Apr	256	8	15	21 May	258	2	40
372	♂	10 Ap	235			2 Ap	252		17	21 Ap	254	2	19
409	♂	24 Ap	193			21 Ap	214		21	31 May	214	0	40
411	♀	24 Ap	221			18 May	221	0	0				
412	♂	24 Ap	233			7 Ap	236		3	22 My	236	1	45
413	♂	24 Ap	236	8 my	+12	21 Ap	258	10	22	5 Jun	263	5	45
414	♀	24 Ap	223			16 Ap	227		4				
415	♂	24 Ap	231			7 Ap	249		18	22 My	251	2	45
416	♂	25 Ap	257			17 Ap	260		3	31 My	260	0	44
417	♂	25 Ap	253	9 My	+4	12 Ap	257	0	4	27 My	259	2	45
418	♂	25 Ap	255	8 My	+8	21 Ap	273	10	18	28 My	276	3	37
419	♂	25 Ap	293			27 Ap	294		1				
425	♀	25 Ap	247			5 Ap	247		0	21 my	246.5	-0.5	46
426	(3) A ♀	26 Ap	193	11 my	+4	3 Ap	197	0	4				
427	♀	26 Ap	215			28 Ap	216		1				
429	♂	26 Apr	158			3 My	216		58				
430	♀	26 Apr	229*			21 Ap	217		-12*	29 my	217	0	38
431	♂	26 Apr	255			20 Ap	255		0	30 MY	256	1	40
432	A ♀	27 Ap	196			11 MY	197		1				
433	♂	27 Ap	270	12 MY	+3	8 Ap	274	1	4				
434	♀	27 Ap	109	12 my	+26	3 Jun	179	44	70				
436	♀	27 Ap	208			4 MY	211		3	9 Jun	211	0	36
438	♂	27 Ap	254			2 Ap	264		10				
440	♂	28 Ap	212			10 My	230		18	6 Jun	230.5	0.5	27
441	♂	28 Ap	213			3 Ap	223		10	1 Jun	227	4	59

Continued

Appendix E

Tortoise #	Sex	Capt 1977	CL (mm)	Capt 1978	Δ CL	Capt. 1980	CL	Δ CL 78-80	(mm) 77-80		Remeas. 1980	CL	Δ CL	# Days	Remeas. 1980	CL	Δ CL	# Days
443	♀	28 Ap	210			5 MY	215		5									
444	♀	28 Ap	151			13 Ap	215		64									
447	♂	28 Ap	232			8 Ap	237		5									
448	♂	29 Ap	270			26 Ap	270		0									
449	♂	29 Ap	175			16 Ap	231		56									
450	J	29 Ap	74			3 MY	121		47									
451	♀	29 Ap	205	11 MY	+8	3 Ap	234	21	29									
452	♂	29 Ap	267			3 Ap	270		3									
453	♀	29 Ap	206			4 MY	215		9		20 my	215	0	16				
454	♂	29 Ap	260	10 MY	+2	31 MY	263	1	3									
455	♀	29 Ap	227	9 MY	-1	4 MY	226	0	-1									
493	♂	8 MY	247	9 MY	+9	27 MY	271	15	24									
494	♂	9 MY	171			11 Ap	235		64		8 Jun	243	8	58				
495	♂	9 MY	259			3 Ap	280		21									
497	♀	9 MY	148			28 Ap	206		58									
500	♂	9 MY	243			13 Ap	255		12		28 my	258	3	45				
502	♂	9 MY	240			10 Ap	250		10		3 Jun	251	1	54				
503	♂	9 MY	196			14 Ap	244		48									
505	♀	10 MY	217	8 MY	+0.5	3 Ap	217	-0.5	0		28 my	218	1	55				
506	♀	10 MY	220			19 Ap	222		2		16 my	223	1	27	11 Jun	223	0	26
508	♂	10 MY	206			10 Ap	247		41		3 Jun	253	6	54				
509	♀	10 MY	209			6 MY	211		2		15 my	211.5	0.5	9				
510	♂ J	11 MY	105			6 MY	161		56									
511	A ♀	11 MY	197			16 Ap	199		2									
512	♀	11 MY	238			16 Ap	238		0		8 Jun	238	0	52				
513	♂	11 MY	170			5 Ap	224		54		8 Jun	232.5	8.5	64				
514	♀	11 MY	211			21 Ap	214		3									
515	A ♀	12 MY	205			27 Ap	205		0		18 my	204	-1	21				
516	♀	12 MY	232	19 MY	+2	6 MY	232	-2	0		29 my	232.5	0.5	23				
517	♂	12 MY	219			19 Ap	228		9									
524	♂	12 MY	270			16 MY	269		-1									
525	♂	13 MY	166			24 MY	202		36		1 Jun	202	0	37				
527	♀	13 MY	182			11 Ap	217		35									
529	J ♀	13 MY	111	9 MY	+17	28 Ap	167	39	56		5 Jun	176	9	38				

Continued

Appendix E

Tortoise #	sex	Capt 1977	CL (mm)	Capt. 1978	Δ CL	Capt. 1980	CL	Δ CL 78-80	mm 77-80		Remeas. 1980	CL	Δ CL	# Days
531	♀	13 my	199	11 my	+12	4 Apr	218	7	19		20 my	225.5	7.5	46
532	♀	14 my	210			17 Ap	209		-1					
533	♀	14 my	216			14 Ap	218		2		11 my	217	-1	27
534	♂	14 my	277			4 Ap	276		-1					
578	♀	23 my	215			8 Jun	217		2					
579	♂	23 my	280			12 my	281		1					
584	♂	24 my	273	11 my	+3	10 Ap	278	2	5		29 my	280	2	49
585	♂	25 my	233			21 Ap	247		14					
590	♀	26 my	219			9 Ap	220		1					
591	♀	26 my	223			12 my	226		3		8 Jun	226	0	27
592	♀	27 my	175			8 Ap	224		49		2 Jun	227	3	55
593	♀	27 my	169			21 Ap	183		14		27 my	184	1	36
595	♀	27 my	205			7 Ap	211		6					
597	♂	29 my	265	18 my	+1	14 Ap	268	2	3		29 my	268	0	45
603	♂	29 my	205			21 Ap	243		38		5 Jun	251	8	45
631	J ♀	8 Jun	104			8 Ap	169		65					
632	♂	8 Jun	262			1 Apr	272		10					
Tortoises marked during 1978														
					CL									
11	♂			8 May	211	Ap	229	18						
12	♂			8 my	220	3 Ap	240	20			9 Jun	244	4	67
13	A ♀			9 my	204	14 my	205	1						
14	♀			9 my	197	17 Ap	200A	3			22 my	200	0	35
16	♀			9 my	219	18 Ap	224	5						
17	♀			10 my	218	7 Ap	217	-1						
18	♀			10 my	195	8 Ap	209	14			31 my	212.5	3.5	53
20	♀			10 my	151	24 Ap	205	54			28 my	206	1	34
27	♂			12 my	259	11 Ap	260	1						
30	♂			18 my	284	29 Mar	283	-1						
31	♂			19 May	217	31 Mar	233	16			30 my	243.5	10.5	60
32	♂			19 May	156	19 Ap	187	31						

Continued

Tortoises marked in 1980 (only those remeasured in 1980)

Tortoise #	Sex	Initial capture	CL (mm)	Remeas. date	CL	Δ CL	# days	Remeas date	CL	Δ CL	# days	Remeas. date	CL	Δ CL	# days
2	J	4 Apr	151	22 May	155	4	48								
5	♂	30 Mar	257	30 May	263	6	61								
6	♂	30 Mar	244	21 May	245	1	52								
8	♀	31 Mar	221	30 MY	221	0	60								
33	♂	9 Apr	182	28 my	194	12	49	6 Jun	197	3	9				
35	♀	31 Mar	198	30 MY	203.5	5.5	60								
39	J	14 Ap	149	20 my	158	9	36	2 Jun	160	2	13				
40	♂	2 Ap	268	1 Jun	268	0	59								
45	♀	3 Ap	201	30 May	215	14	57								
46	♂	3 Ap	275	3 Jun	281	6	61								
47	♀	4 Ap	219	7 Jun	221.5	2.5	64								
48	♀	4 Ap	215	16 MY	217	2	40								
50	♂	4 Ap	257	20 MY	257	0	46								
51	♂	5 Ap	268	29 MY	267.5	-0.5	54								
52	J	5 Ap	151	21 my	154	3	49								
54	♂	5 Ap	280	5 Jun	284.5	3.5	61								
55	♂	8 Ap	220	5 Jun	226.5	6.5	58								
56	♂	8 Ap	240	7 Jun	241	1	60								
57	J	8 Ap	162	2 Jun	174	12	55								
58	♀	9 Ap	227	28 MY	228	1	49								
59	J	9 Ap	174	30 my	186.5	12.5	51								
60	♂	13 Ap	257	4 Jun	257	0	52								
68	♂	12 Ap	219	22 MY	225	6	40								
69	♂	12 Ap	245	5 Jun	246	1	54								
70	♂	12 Ap	307	9 Jun	307	0	58								
71	♀	9 Ap	228	1 Jun	228	0	53								
72	J	9 Ap	99	30 MY	108	9	51								
74	♂	13 Ap	252	10 Jun	256	4	58								
75	♂	14 Ap	277	7 Jun	277	0	54								
81	♂	4 Ap	172	2 Jun	185.5	13.5	59								
82	J	16 Ap	109	30 MY	116.5	7.5	44								
85	♂	17 Ap	266	9 Jun	270	4	53								
88	J	17 Ap	162	20 my	166	4	33	5 Jun	171	5	16				
92	J	21 Ap	124	9 Jun	131	7	49								
94	♂	17 Ap	187	27 my	193	6	40								
[illegible]6	♀	18 Ap	219	28 my	219	0	[illegible]								

Continued

Appendix E

Tortoise #	Sex	Initial Capture	CL (mm)	Remeas. date	CL	Δ CL	# days	Remeas. date	CL	Δ CL	# days	Remeas.	CL	Δ CL	# days
99	J	25 Ap	70	2 Jun	76	6	38								
100	J	25 Ap	165	20 my	171	6	25								
101	J	26 Ap	122	16 My	125.5	3.5	20	8 Jun	132	6.5	23				
104	♂	19 Ap	209	11 my	212	3	22	11 Jun	215	3	30				
108	J	28 Ap	156	28 my	164	8	30	1 Jun	166	2	4	10 Jun	168	2	9
112	J	2 My	62	7 Jun	71	9	36								
113	J	2 my	145	29 my	147	2	27								
114	♂	20 Ap	201	21 my	204	3	31	8 Jun	210	6	18				
117	♂	24 Ap	256	6 Jun	258	2	43								
120	J	24 Ap	141	6 Jun	142	1	43								
123	♂	24 Ap	182	28 my	188	6	34	1 Jun	190	2	4	6 Jun	190	0	5
126	♀	26 Ap	217	11 Jun	217	0	46								
129	♂	26 Ap	270	3 Jun	270	0	38								
130	J	2 my	126	29 my	133.5	7.5	27								
131	J	3 my	147	21 my	153	6	18								
142	♀	2 my	218	20 my	220	2	18	2 Jun	220	0	13				
144	♂	3 my	194	29 my	198.5	4.5	26								
145	♂	4 my	210	9 Jun	210	0	36								
147	♂	4 my	252	27 my	252.5	0.5	23								
149	♂	8 my	198	29 my	201	2	21								
150	♂	10 my	208	28 my	211.5	3.5	18	6 Jun	211.5	0	9				
153	♀	13 my	203	22 my	205	2	9								
155	♀	14 my	222	6 Jun	224	2	23								
157	J	19 my	150	10 Jun	160	10	22								
164	♀	22 my	221	30 my	221	0	8								
167	♂	30 my	207	11 Jun	208	1	12								
176	J	6 Jun	141	10 Jun	141.5	0.5	4								
182	J	7 My	139	30 my	141	2	23								
188	J	9 my	144	5 Jun	151	7	27								
190	J	10 my	109	28 my	113.5	4.5	18								

① Burge. 1977 ② Nicholson. 1978

③ A = Adult. although < 208 mm. on basis of heavy shell wear, minimal growth, or excessively shortened nuchal or post vertebral scutes

* Errors: should be 219 mm and −2 mm respectively. Negative values are within the range of various errors (see Methods and Discussion).

Growth of tortoises remeasured during 1980 listed by Sex and length at initial measurement in 1980

	Tortoise #	Initial CL 80	ΔCL (+mm)	# days	mm/day $\bar{x}$
Unsexed juveniles					
	112	62	9	36	.25
	99	70	6	38	.16
	72	99	9	51	.18
	82	109	7.5	44	.17
	190	109	4.5	18	.25
	101	122	10	43	.23
	92/130	124/126	7.5	49/27	.14/.28
	182	137	2	23	.09
	120	141	1	43	.02
	176	141	0.5	4	.13
	188	144	7	27	.26
	113	145	2	27	.07
	131	147	6	18	.33
	39	149	11	49	.22
	157	150	10	22	.45
	2	151	4	48	.08
	52	151	3	49	.07
	108	156	12	43	.28
	57	162	12	55	.22
	100	165	6	25	.24
	59	174	12.5	51	.25
♀♀	529	167	9	38	.24
	593	183	1	36	.03
	35	198	5.5	60	.09
	14A	200	0	35	0
	45	201	14	57	.25
	153	203	2	9	.22
	20	205	1	34	.03
	515A	205	-1	21	0
	18	209	3.5	53	.07
	436	211	0	36	0
	509	211	.5	9	.06
	453	215	HL	16	HL*
	48	215	2	40	.22
	126	217	0	46	0
	430	217	0	38	0
	505	217	1	55	.02
	533	218	-1	27	0
	531	218	7.5	46	.16
	142	218	2	18	.11
	47	219	2.5	64	.04
	96	219	0	40	0
	366	220	HL	24	HL
	164	221	HL	8	HL
	8	221	0	60	0

	Tortoise #	Initial CL 1980	ΔCL (+mm)	# days	mm/day $\bar{x}$
♀♀	506	222	1	27	.04
	155	222	2	23	.09
	592	224	3	55	.05
	591	226	0	27	0
	58	227	1	49	.02
	71	228	0	53	0
	516	232	.5	23	.02
	364	233	1	16	.06
	512	238	0	52	0
	425	247	-.5	46	0
♂♂	88	162	9	49	.18
	81	172	13.5	59	.23
	123	182	8	43	.21
	33	182	15	58	.26
	94	187	6	40	.15
	144	194	4.5	26	.17
	149	198	2	21	.10
	114	201	9	49	.18
	525	202	HL	37	HL
	167	207	1	12	.08
	150	208	3.5	15	.19
	104	209	6	52	.12
	145	210	HL	36	HL
	409	214	HL	40	HL
	68	219	6	40	.15
	55	220	6.5	58	.11
	441	223	4	57	.07
	513	224	8.5	64	.13
	357	230	4.5	55	.08
	440	230	.5	27	.02
	31	233	10.5	60	.18
	494	235	8	58	.14
	412	236	1	45	.02
	359	237	1	49	.02
	12	240	4	67	.06
	56	240	1	60	.02
	603	243	8	45	.18
	6	244	1	52	.02
	69	245	1	54	.02
	508	247	6	54	.11
	365	248	2	40	.05
	415	249	2	45	.04
	502	250	1	54	.02
	372	252	2	19	.11
	147	252	0.5	23	.02
	74	252	4	58	.07

continued.

Appendix F

	Tortoise #	Initial CL 1980	Δ CL	# days	mm/day $\bar{X}$		
EE	500	255	3	45	.07		
	431	255	1	40	.03		
	117	256	2	43	.05		
	369	256	2	40	.05		
	50	257	0	46	0		
	417	257	2	45	.04		
	5	257	6	61	.10		
	60	257	0	52	0		
	413	258	5	45	.11		
	416	260	0	44	0		
	85	266	4	53	.08		
	597	268	HL	45	HL		
	40	268	0	59	0		
	51	268	-0.5	54	0		
	129	270	0	38	0		
	418	273	3	37	.08		
	46	275	6	61	.10		
	75	277	0	54	0		
	584	278	2	47	.04		
	54	281	3.5	61	.06		
	367	284	0	43	0		
	70	307	0	58	0		
58							

* HL= Hair-line of new material visible in seams
A= Considered an adult

Appendix G

Tortoises marked in 1980: Complete measurements at initial capture

Tortoise #	SEX	MCL (mm)	WIDTH at SEAM M3-4	WIDTH at SEAM M7-8	Gr W @	Ht C(V)3	Pl. Length notch	Pl. length Total	Wt g	Comments: Injuries, Anomalies, Parasites, behavior (Not complete)	DATE Marked 1980
1	J	113	80	90	92 [5]	55	103	116	361		29 Mar
2	J	151	98	103	110 [5,6]	70	135	151	665		4 Apr
3	J	100	71	75	79 [8]	46	90	99	208		7 Apr
4	♀	229	161	189	193 [8]	111*	209	225	2365	Heavy shell wear, sunken scutes (depressed centers)	30 Mar
5	♂	257	171	191	196 [8]	115	232	254	2915		30 Mar
6	♂	244	169	188	193 [5,6]	114	219	244	2915		30 Mar
7	♂	269	192	216	222 [6]	122	250	268	3615	Eating Pectocarya recurvata + Camissonia	30 Mar
8	♀	221	153	173	177 [8]	101	197	225	2315		31 Mar
9	J	93	63	70	71 [8]	46	85	90	62		5 Apr
10	J	92	66	69	74 [5]	44	85	92	182		11 Apr
33	♂	182	122	129	138 [5]	84	164	184	1115	1 soft tick at rest on carapace	9 Apr
34	♂	270	200	212	220 [9]	129	267	286	4040	• Heavy shell wear. Eats HIRI	31 Mar
35	♀	198	120	153	156 [6]	97	176	183	1740	• Eating	31 Mar
36	♀	217.5	138	160	162 [8]	91	192	215	2213	•	2 Apr
37	♀	220	143	171	174 [8]	102	192	215	2013	• Heavy shell wear + chipping	2 Apr
38	J	137	88	108	111 [6]	85	128	139	615	Carapace scutes somewhat depressed not vigorous	9 Apr
39	J	149	97	107	113 [8]	69	132	144	715		14 Apr
40	♂	268	193	216	223 [7]	123*	244	268	4090	• Heavy shell wear + chipping, Eating; car. scutes depressed	2 Apr
41	♂	247	178	195	200 [8]	115	222	247	3015	•	3 Apr
42	♀	227	148	171	173 [8]	102	209	229	2365	• Eating Lupinus concinnus orcuttii	3 Apr
43	♀	183	115	130	135 [8]	82	163	178	1115		3 Apr
44	♀	209	139	156	161 [8]	93	190	208	1665		3 Apr
45	♀	201	127	148	150 [8]	91	176	195	1665		3 Apr
46	♂	275	183	223	228 [8]	122	245	268	3865	Heavy shell wear, some chipping	3 Apr
47	♀	219	152	173	177 [5,6]	102	201	219	2265		4 Apr
48	♀	215	147	159	163 [5,8]	95	191	210	1665	• 10 Left marginals	4 Apr
49	♀A†	203	144	173	177 [8]	93	187	209	1915	• Heavy shell wear	4 Apr
50	♂	257	173	200	214 [8]	110*	233	253	2915	• Heavy shell wear, depressed, Rt front nails 3+4 nubs	4 Apr
51	♂	268	184	218	227 [8]	127	245	269	3365	Heavy wear plus chipping. Eating LOTO	5 Apr
52	J	151	103	113	119 [5]	73	132	147	715		5 Apr
53	♂	268	180	205	213 [8]	119	251	266	3315	• Eating Cryptantha micrantha	5 Apr
54	♂	281	190	224	231 [6]	131	264	286	4340	•	7 Apr
55	♂	220	152	163	175 [6]	105	203	224	2140		8 Apr
56	♂	240	172	196	198 [7]	112	226	244	2865	• Heavy shell wear, some chipping, whitening	8 Apr
57	J	162	113	127	131 [6]	79	150	165	1015	misfire marks RM3 + LM3	8 Apr
58	♀	227	148	174	178 [7]	102	205	233	2365	•	9 Apr
59	J	174	115	134	137 [7]	79	165	179	1115	• 12 Left marg.	9 Apr
60	♂	257	182	198	205 [5,8]	126	247	263	3665	• mod wear + chipping	13 Apr
61	♂	207	143	166	168 [8]	103	190	213	1915	mod. wear, heavy chipping	9 Apr
62	♂	274	189	215	220 [8]	124	249	271	3915		10 Apr
63	J(♀)	174	118	131	136 [6]	78	160	177	1065		10 Apr
64	J(♂)	164	108	126	129 [7]	84	144	161	990		11 Apr
65	J	170	113	123	128 [8]	77	146	170	1015	misfire mark LM5 Eating LOTO	11 Apr

* Greatest height which typically occurs at mid-Central (vertebral) 3; Where scute centers are depressed the bar calipers touch only scute edges.

** Length not representative because of injury or anomaly

• Includes most with any indication of injury, however slight, with the exception of wear and notching of the post central scute (#?)

† Considered an adult - A

(Continued)

Appendix G

Gopherus agassizi Measurements at initial Capture Study Plot: GOFFS 1980

Tortoise #	SEX	MCL (mm)	Width at seams m 3-4	Width at seams M 7-8	Gr W @	Ht C(V)3	Pl. L notch	Pl. L Total	Wt. g	COMMENTS: Injuries, anomalies, Parasites, Behavior	Date Marked 1980
66	♂	250	178	205	212 ^{7}	120	229	250	3140		12 Apr
67	♀A	204	142	160	164 $^{5}_{6}$	90	172	202	1865	°Heavy shell wear, some whitening and CHIPPING	12 Apr
68	♂	219	152	164	170 ^{7}	103	199	225	2165	°	12 Apr
69	♂	245	166	193	203 ^{8}	112	233	258	3065	°	12 Apr
70	♂	307	208	243	250 ^{8}	145	285	314	≈6000	largest tortoise, voided during most procedures	12 Apr.
71	♀	228	157	183	189 ^{6}	100	210	233	2665	Heavy wear, Chipping	9 Apr.
72	J	99	71	81	82 ^{6}	48	90	98	214	Eating	9 Apr.
73	J	112	77	85	88 ^{5,6}	52	101	109	336		9 Apr
74	♂	252	182	209	210 $^{7}_{8}$	117	238	264	3415	Heavy shell wear, 8 ~~soft~~ ticks on shell	13 Apr
75	♂	277	197	219	222 $^{5}_{6}$	124	261	282	4290	Heavy wear + Chipping	14 Apr
76	♂	281	202	222	229 $^{5}_{6}$	129	260	288	4740	Heavy wear, 2 ~~soft~~ ticks on shell	14 Apr
77	♂	196	130	148	152 ^{8}	93	177	199	1565		16 Apr
78	♀	218	147	170	177 ^{8}	92	191	230	1913	Several slight old injuries Eating LOTO	16 Apr
79	♂	218	144	163	166 ^{8}	97	192	213	2015	Eating	16 Apr.
80	J	167	108	123	126 ^{8}	80	159	171	915	1 ~~soft~~ tick at least on shell	17 Apr
81	J(♂)	172	116	127	132 ^{6}	83	158	174	1115	°RM 9+10 appear doubled	4 Apr
82	J	109	75	82	84 ^{8}	55	98	107	336		16 Apr
83	J	123	82	90	93 ^{5}	59	107	121	442		20 Apr
84	♂	248	173	193	198 ^{8}	103	221	244	2890	12 ~~soft~~ ticks on shell	17 Apr
85	♂	266	178	207	213 ^{8}	122	232	259	3765		17 [illegible]
86	♂	230	151	175	182 ^{8}	112	207	234	2615	°several old sli. injuries + Chipping	1[illegible]
87	♀	208	137	156	161 ^{8}	93	188	202	1813		17 Apr
88	J(♂)	162	114	124	127 ^{8}	74	146	161	915	°extensive whitening of scute surfaces	17 Apr
89	J	53	40	43	44 ^{7}	26	49	50	36	2 growth rings	19 Apr
90	J	122	83	93	95 $^{6}_{7}$	59	113	123	465		20 Apr
91	J	129	84	99	100 ^{6}	59	113	126	515	12 marginals bilat.	21 Apr
92	J	124	85	94	98 $^{5}_{6,7}$	58	111	123	440	Whitening of carapace + shedding of V3	21 Apr
93	J	110	73	81	83 ^{8}	52	100	107	315		21 Apr
94	♂	187	125	135	138 ^{8}	88	174	184	1465	°Extra L+R m 1a; old injury	17 Apr
95	♂	214	139	157	162 ^{8}	97	198	21[illegible]	2815		18 Apr
96	♀	219	154	172	177 ^{7}	105	199	222	2313	Heavy shell wear	18 Apr
97	♂	264	181	205	216 ^{8}	117	246	266	3715	°Heavy wear, some chipping	19 Apr
98	J	84	58	67	69 ^{6}	39	76	81	134		25 Apr
99	J	70	51	55	58 ^{6}	33	62	65	78	3 gr. rings	25 Apr
100	J	165	111	121	125 $^{5}_{6}$	81	148	163	1015		25 Apr
101	J	122	80	90	93 ^{5}	69	109	113	440		26 Apr
102	J	48	36	40	43 ^{6}	24	45	51	30	2 growth rings	26 Apr
103	J	119	80	90	95 ^{6}	59	107	118	440		28 Apr
104	♂	209	139	163	169 ^{8}	99	183	200	1715	°old gular injury (ventral)	19 Apr
105	J	146	96	109	113 ^{5}	68	133	145	715	°old gular injury	19 Apr
106	♂	255	191	207	210 ^{8}	120	247	269	3415	°	20 Apr

(continued)

Gopherus agassizi Measurements at initial capture Study Plot: GOFFS 1980

Tortoise #	SEX	MCL (mm)	Width at Seams M 3-4	Width at Seams m 7-8	Gr. W @	Ht C(V)3	Pl. L notch	Pl. L Total	Wt (g)	COMMENTS:	Date marked 1980
107	♀	218	140	165	166^{8}	101	197	208	2765	•Pl. tips of anal scutes gone; Eats LOTO	20 Apr
108	J	156	102	119	124^{6}	74	146	159	840		28 Apr
109	J	60	45	48	$51^{5/6}$	28	55	57	44	vermiculations under areolae	28 Apr
110	J	47	36	39	$41^{5/6}$	24	43	44	27	2 gr. rings	27 Apr.
111	J	56	43	44	48^{6}	27	55	56	46	Eating LOTO	28 Apr
112	J	62	47	52	$53^{5/6}$	32	55	59	60	Scutes of shell depressed - not healthy looking	2 May
113	J	145	97	107	112^{5}	69	128	140	665		2 May
114	♂	201	134	148	157^{6}	101	173	200	1715	•	20 Apr.
115	♀	216	142	163	169^{8}	92	198	217	2065		21 Apr.
116	♂	249	168	194	199^{8}	115	230	253	3190	Heavy wear, Some Chipping	21 Apr
117	♂	256	179	209	214^{8}	117	231	257	3415	5 Rt Costals Rt depression (where soil eaten)	24 Apr
118	♂	213	140	162	168^{5}	98	191	211	1890	•Post central scute pitted (pred.) old	24 Apr
119	♂	183	116	135	142^{8}	83	161	183	1215	partially divided nuchal	24 Apr
120	J	141	94	110	111^{8}	67	128	141	615		24 Apr
121	J	70	53	52	59^{7}	36	62	65	90	10 marg. bilat. No seam betw V4+5	2 May
122	J	91	61	70	70^{4-7}	44	82	90	169	Chipping + Whitening (wear minimal)	4 May
123	♂	182	120	136	143^{8}	84	173	189	1315	•	24 Apr
124.	♂	229	143	180	182^{7}	110	212	238	2765	•old inj. humerals, L Costal 1, anterior marg.	24 Apr
[illegible]	♀	204	144	166	169^{8}	87	190	209	1765	whitening of carapace. ~~Eating~~ Pectocarya recurvata	25 Apr
[illegible]	♀	217	145	171	175^{6-7}	102	203	221	2290	Heavy wear + Chipping, Nuchal Cleft	26 Apr
[illegible]	♀A	195**	138	155	159^{8}	95	184	206	1815	•old inj. anterior carap., gular, left humeral; 5 ticks; whitening	26 Apr.
128	♂	255	183	208	216^{8}	111*	234	254	3115	•Heavy wear, car. scutes depressed	26 Apr
129	♂	270	191	212	$215^{5/6}$	125	250	272	4490	•Heavy wear, Whitening, 1 soft tick at soil depression	26 Apr
130	J	126	80	90	96^{5}	59	112	124	463		2 May
131	J	147	100	113	115^{5}	71	135	146	713		3 May
132	J	104	71	78	81^{5}	52	95	102	313	Eating soil	4 May
133	J	118	78	91	$92^{6/7}$	60	108	118	465	Moderate shell wear + Chipping	29 Apr
134	♂	212	142	159	162^{8}	97	199	215	1915		27 Apr
135	♂	187	125	143	146^{6}	91	162	184	1415	•inj. old: gular, humeral, ant. marg. left front nails = nubs (pred.)	27 Apr
136	♂	195	128	145	149^{8}	92	176	189	1615	Whitening of femorals + anals	28 Apr
137	J	141	99	105	109^{8}	68	125	138	688	1 soft tick	5 May
138	J	111	74	83	87^{6}	54	100	107	363	Rt anal reduced	5 May
139	J	102	71	79	82^{5}	49	89	98	236		5 May
140	♂	264	178	206	213^{8}	115*	240	264	3665	Heavy Wear, depressed scutes, Chipping	29 Apr
141	♂	231	151	179	193^{8}	104	214	231	2540	Heavy shell wear	2 May
142	♀	218	143	159	165^{8}	98	200	215	2115		2 May
143	♂	236	156	171	179^{8}	111	211	230	2565	•irregular ant. Car. marg.; Whitening	2 May
144	♂	194	126	144	148^{8}	88	172	192	1513		3 May
145	♂	210	131	153	159^{8}	97	185	202	1863	•1 Tick	4 May
146	♂	253	184	211	219^{8}	117*	229	246	3765	•Heavy wear, Eats LOTO, scutes depressed, 1 Tick	4 May

(Continued)

Appendix G

Gopherus agassizi: Measurements at initial capture   study Plot: GOFFS   1980

Tortoise #	SEX	MCL (mm)	Width at Seams M3-4	Width at Seams M7-8	Gr. W @	Ht C(v)3	Pl. L notch	Pl. L Total	Wt. (g)	Comments:	Date marked 1980
147	♂	252	161	181	188 [8]	110	230	255	3215	°mod. wear + Chipping	4 May
148	♂	271	197	222	235 [8]	119	255	278	4290	Heavy Shellwear	7 May
149	♂	198	127	142	146 [8]	93	175	187	1640	5 left Costals	8 May
150	♂	208	138	156	161 [8]	102	192	209	1915		10 May
151	♂	194	130	147	149 [8]	90	175	190	1663	1 Tick	11 May
152	♀	175	123	134	137 [5]	82	162	173	1213	°old injury RC1	13 May
153	♀	203	133	158	163 [6]	91	176	200	1913	mod. wear + Chipping	13 May
154	♂	268	185	205	209 [8]	120	216	236	3790	°Heavy wear, depressed scutes some chipping	13 May
155	♀	222	159	175	179 [7]	107	204	225	2663		14 May
156	J ♂	171	107	120	122 [8]	80	147	163	1013	air spaces under several car. scutes.	15 May
157	J	150	100	113	119 [6]	72	134	146	838		19 May
158	♂	199	137	155	159 [8]	97	180	193	1788	°[illegible] old inj LM1 + nuchal	19 May
159	J	153	98	115	118 [6]	74	135	152	863		20 May
160	♂	235	168	187	193 [6]	111	229	245	2865	°whitening of marginals + plastron (abd)	20 May
161	♀	231	153	175	181 [6]	104	216	234	2613	°Eating LOTO	21 May
162	J ♂	169	116	133	135 [8]	82	159	173	1213		22 May
163	J	152	104	120	123 [3]	76	137	154	913	air spaces under areolae	22 May
164	♀	221	155	177	180 [8]	96	197	218	2363	°Heavy wear + Chipping, depressed scutes	22 May
165	J	152	104	119	122 [8]	73	135	149	863	Whitening LC 3,4 and V 4,5 Eating LOTO	22 May
166	J	160	105	113	118 [6]	75	144	163	913	Whitening (on bridge especially)	2[illegible]
167	♂	207	138	158	162 [8]	98	191	213	2038		3[illegible]
168	J	160	101	115	118 [8]	74	139	156	888	vermiculations under some scutes	31 May
169	♀	190	122	136	142 [6]	89	170	186	1463		31 May
170	♂J	179	118	135	139 [8]	83	159	180	1263		31 May
171	♂J	178	121	134	137 [6]	83	165	183	1388	10 LMS 11 RM reduced Chipwear + whitening	2 June
172	♂J	176	112	129	133 [6/8]	82	162	174	1213	5 L C's Symmetrical false seams on LC5 + RC4	3 June
173	♀A	197**	140	157	163 [8]	91	191	208	1838	°airspaces under + Chipping of ant. areolae	6 June
174	J	123	83	94	97 [6]	59	110	122	488		6 June
175	J	107	74	84	88 [6]	52	96	106	315	4 distinct gr. rings + this season's	6 June
176	J	141	91	103	107 [8]	66	126	139	613	12 marginals bilat. vermiculations under areolae	6 June
177	J **	147 (155)	102	111	113 [8]	71	136	146	788	divided + forked post. central	6 May
178	♂	168	110	125	129 [8]	81	151	160	1113	°tip of rt anal gone Eating LOTO	8 May
179	J	113	77	83	87 [5]	53	102	112	363	5 RC's airspaces under areolae	14 May
180	J	108	72	81	83 [8]	52	100	106	288	°vermiculations under areolae	14 May
181	J	113	74	83	87 [5]	50	97	109	313	Eating LOTO	5 May
182	J	139	95	102	106 [5]	66	125	136	663	Eating LOTO	7 May
183	J ♂	177	119	127	132 [7]	82	156	173	1263		7 May
184	J	118	79	89	91 [8]	55	104	114	388	false seam and notch of post central	16 May
185	J (♂)	138	93	102	106 [5]	65	122	135	613		18 May
186	J	111	69	76	77 [8]	46	88	98	263		18 May

(Continued)

Appendix G.

Gopherus agassizi Measurements at initial Capture Study Plot: GOFFS 1980

Tortoise #	SEX	MCL (mm)	Widths at seams M 3-4	Widths at seams M 7-8	GrW @	Ht C(V)3	Pl. L notch	Pl. L Total	Wt (g)	Comments	Date marked 1980
187	J	125	88	99	104^{6}	59	110	121	465		19 May
188	J	144	95	104	109^{6}	73	122	138	763		9 May
189	J	111	74	82	88^{5}	55	103	109	363		9 May
190	J	109	73	80	82^{6}	51	95	104	311	Chipwear (premature), Eating soil, mod. wear	10 May
191	J	92	61.5	67	73^{5}	46	82	89	186	Lizard scat in mouth	12 May
192	J	113	77	87	88^{5}_{6}	54	102	111	363	eating lupine LUCOOR	13 May
193	J	136	88	98	103^{6}	62	118	134	588		13 May
194	♂	221	140	163	167^{8}	103	200	221	2015		11 June
195	J	110	75	82	87^{6}	54	101	110	336	whitening of ant. marg.	11 June
196	J	87	60	66	67^{6}_{8}	40	79	83	138		11 June
197	J	133	86	99	102^{8}	63	118	132	515	Left hind lower leg missing, a callosed stump	11 June
198	J	101	67	74	77^{6}	47	90	97	210	whitening, air spaces under areolae	20 MAY
199	J	69	48	55	58^{8}	32	62	66	70	vermiculations + air spaces under areolae Eating soil	29 May
200	J	77	53	58	60^{5}	38	69	75	106		14 May
201	J	53	39	43	46^{5-7}	27	50	52	39	Eating LOTO	18 May
202	J	72	51	56	58^{6}	33	65	68	83		27 May
203	J	85	60	65	69^{5}	41	75	81	138	vermiculations under areolae	27 May
204	J	125	83	92	94^{5}_{6}	69	109	118	463	vermiculations + air spaces under areolae	2 June
[illegible]05	J	121	82	93	99^{5}	67	112	121	463	5 V's vermiculations car + pl.	4 June
[illegible]	J	105	69	81	82^{8}	51	92	100	256	whitening and chipping	5 June
[illegible]7	J	113	75	84	86^{5}	55	99	110	363		7 June
208	J	53	41	43	47^{5}_{6}	27	49	52	40		27 May
209	J	66	50	54	55^{5}_{6}	32	60	63	73	some vermiculations	31 May
210	J	95	66	72	78^{5}	45	88	94	192	Vermiculations	3 June
211	J	69	49	54	56^{6}	34	63	67	79		7 June
212	J	86	60	66	68^{6}	40	75	82	136	some vermiculations	7 June
213	J	111	74	81	83^{8}	53	100	107	315	average width of new growth at seams 2 mm	8 June
214	J	158	102	110	120^{5}	75	141	156	938		6 June
215	J	131	90	101	105^{5}	62	122	132	540		7 June
216	♀	179	120	136	141^{5}	81	157	181	1365		8 June
217	♀	221	151	171	176^{8}	101	208	228	2415	Eating LOTO (green)	9 June
218	J	99	66	74	75^{5}	45	88	95	206	Eating soil from freshly dug hole	8 June
219	J	143	95	111	112^{8}	62	134	146	665		9 June
220	J	169	103	124	128^{6}	81	152	165	1040	2 extra "nuchals" 1 TICK	11 June
221	♀	210	139	167	170^{8}	97	188	222	2265	Heavy wear, chipping, old injury ventral area of gular	11 June

Total: 199 tortoises marked. Some tallies will include ♀506 and ♂372 marked outside the study plot in 1977 and recaptured inside during 1980 or a total of 201 "new" tortoises on the study plot.

Growth (carapace length) of tortoises marked during 1977 and 1978 listed by sex and initial length

1977	Tortoise #	Initial CL 1977 ①	1980	ΔCL ② 77-80	mm/yr $\bar{x}$	ΔCL ③ 77-78	mm 78-80	$\bar{x}$/yr 78-80
♂♂								
	510	105	161	56	18.7			
	365	145	193	48	16.0			
	429	158	216	58	19.3			
	525	166	202	36	12.0			
	513	170	224	54	18.0			
	494	171	235	64	21.3			
	449	175	231	56	18.7			
	357	190	230	40	13.3			
	409	193	214	20	6.7			
	503	196	244	48	16.0			
	503	205	243	38	12.7			
	508	206	247	41	13.7			
	440	[illegible]	[illegible]	18	6.0			
	359	213	237	24	8.0			
	441	213	223	10	3.3			
	517	219	228	9	3.0			
	361	222	250	28	9.3	16	12	6
	368	228	248	20	6.7	8	12	6
	415	231	249	18	6.0			
	447	232	237	5	1.7			
	412	233	236	3	1.0			
	585	233	247	14	4.7			
	372	235	252	17	5.7			
	413	236	258	22	7.3	12	10	5
	502	240	250	10	3.3			
	369	241	256	15	5.0	7	8	4
	500	243	255	12	4.0			
	493	247	271	24	8.0	9	15	7.5
	417	253	257	4	1.3	4	0	0
	438	254	264	10	3.3			
	431	255	255	0	0			
	418	255	273	18	6.0	8	10	5
	416	257	260	3	1.0			
	495	259	280	21	7.0			
	454	260	263	3	1.0	2	1	0.5
	632	262	272	10	3.3			
	597	[illegible]	268	3	1.0	1	2	1
	452	267	270	3	1.0			
	433	270	274	4	1.3	3	1	0.5
	[illegible]	[illegible]	[illegible]	0	0			
	584	273	278	5	1.7	3	2	1
	534	277	276	−1	0			
	577	280	281	1	.3			
	367	283	284	1	.3			
	419	293	294	1	.3			

Continued

1977	#	Initial CL mm ① 1977	1980	Δ CL ② 77-80	x̄ mm per yr	Δ CL mm 77-78	78-80	x̄/yr 78-80
	Sex undetermined							
	450	74	121	47	15.7			
♀♀	631	104	169	65	21.7			
	434	109	179	70	23.3	26	44	22
	529	111	167	56	18.7	17	39	19.5
	497	148	206	58	19.3			
	444	151	215	64	21.3			
	593	169	183	14	4.7			
	592	175	224	49	16.3			
	527	182	217	35	11.7			
	426	173A	177	4	1.3	4	0	0
	432	196	197	1	.3			
	511	197	199	2	.7			
	531	199	218	19	6.3	12	7	3.5
	595	205	211	6	2			
	515	205A	205	0	0			
	451	205	234	29	9.7	8	21	10.5
	453	206	215	9	3			
	436	208	211	3	1			
	507	207	211	2	.7			
	532	210	209	-1	0			
	443	210	215	5	1.7			
	514	211	214	3	1			
	427	215	216	1	.3			
	578	215	217	2	.7			
	533	216	218	2	.7			
	366	216	220	4	1.3			
	505	217	217	0	0	.5	-.5	0
	590	219	220	1	.3			
	363	219	222	3	1			
	506	220	222	2	.7			
	411	221	221	0	0			
	414	223	227	4	1.3			
	591	223	226	3	1			
	360	225	228	3	1			
	455	227	226	-1	0	-1	0	-1
	430	229*	217	-12*				
	516	232	232	0	0	+2	-2	-1
	364	233	233	0	0			
	512	238	238	0	0			
	425	247	247	0	0			
39								

1978	Tortoise #	Initial ③ CL 1978	1980	Δ CL 78-80	x̄/yr
♀♀	20	151	205	54	27
	18	195	209	14	7
	14	197	200A	3	1.5
	13	204A	205	1	.5
	17	218	217	-1	-.5
	16	219	224	5	2.5
♂♂	32	156	187	31	15.5
	11	211	229	18	9
	31	217	233	16	8
	12	220	240	20	10
	27	259	260	1	0.5
	30	284	283	-1	-0.5

① Burge, 1977 ② increase unless otherwise stated. Negative values are within the range of precision of method (see under methods and discussion

③ Nicholson, 1978

* The corrected values are 219 and -2 respectively

A Adult

Appendix I

More or less complete shell remains

Field number	Size class and sex	Estimated duration of exposure (relative)	Sign of predation
15 MY-980-2	"Hatchling"	recent	yes
25 AP-980-1	Very young	recent	yes
1 MY-980- 1	Very young	recent	yes
3 MY-980-1	Immature	recent	yes
4 AP-980-5	Subadult female	moderate	yes
4 AP-980-6	Adult female	moderate	yes
5 AP-980-1	Subadult female	moderate	yes
4 AP-980-4	Adult female	long	yes
8 MY-980-1	Adult male	long	possibly